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RED IRON ORES AND FERRUGINOUS SANDSTONES OF THE CLINTON FORMATION IN THE BIRMINGHAM DISTRICT, ALABAMA

BY

W. R. CRANE

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RED IRON ORES AND FERRUGINOUS SANDSTONES OF THE CLINTON FORMATION IN THE BIRMINGHAM DISTRICT, ALABAMA

By W. R. Crane

INTRODUCTION

Although much information is available on the grade of the iron ores in the Birmingham district and numerous analyses of these ores have been published, no attempt has been made to investigate the ores systematically with respect to variations of composition along the strike and down the dip. As available data were limited and representative samples were difficult to obtain, the information given in this paper is incomplete and can not be considered conclusive, but it does, however, indicate what variations may be expected and has been strikingly corroborated by recent developments in the mines, particularly with respect to the grade of ore down the dip.

The economic position of the ferruginous sandstones is quite different from that of the ores, but on account of their relatively high iron content determination of their status as potential sources of iron is important.

All samples were taken by the writer, and the analyses were made by the chemists at the Southern mining experiment station of the Bureau of Mines or by cooperating agencies.

The object of this paper is to show the amount and the grade of all the ferruginous materials of the Clinton formation in the Birmingham district, including the ore beds. Should a successful and satisfactory method for beneficiating the high-silica ores be devised it would apply equally well to the ferruginous sandstones, and the information contained herein would then provide information on the occurrence of supplies of workable materials.

ACKNOWLEDGMENTS

Acknowledgments for data and suggestions are due to many persons who have been or are now actively engaged in mining in the district, particularly to the following members of the advisory committee of the Bureau of Mines: W. J. Penhallegon, general superintendent of ore mines and quarries, Republic Iron & Steel Co., chairman; C. E. Abbott, general manager of mines, Tennessee Coal, Iron & Railroad Co.; C. E. Bowron, chief engineer, Gulf States Steel Co.; W. M. Lacey, former general superintendent,

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Woodward Iron Co.; J. E. Strong, vice president, Alabama Co.; and H. J. Thomas, general superintendent, Sloss-Sheffield Iron & Steel Co. Acknowledgments are also made to the local superintendents and engineers of these companies for assistance freely given.

FIGURE 1.—Outcrop of Big Seam, middle of district

The following Bureau of Mines men gave valuable service in assisting in collecting, preparing, and analyzing samples: Oscar Lee, associate metallurgist; F. D. DeVaney, junior mining engineer; B. W. Gandrud, junior metallurgist; and Jelks Barksdale, assistant analytical chemist. H. F. Anders and R. L. Farabee, analytical chemists and cooperative employees, also rendered valuable assistance in the analysis of ores.

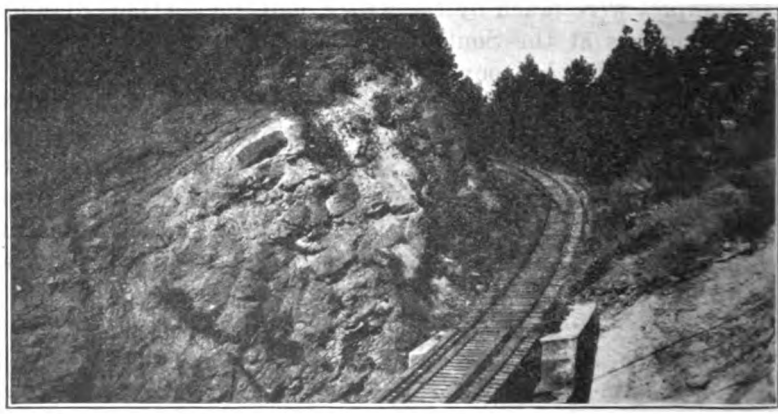

FIGURE 2.—Big Seam exposed in railroad cut

OCCURRENCE OF THE ORES

The ores are hematites and lie as bedded deposits in Red Mountain, which extends northeast and southwest between Birmingham and Bessemer and beyond, although the most important part of the district is between the cities named. The ore beds are in the

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Clinton formation, of Silurian age, which is 200 to 300 feet thick and is composed largely of sandstone and shale.[1]

There are four ore beds in this formation, but only two produce ore suitable for making iron by present conditions. However, as

FIGURE 3.—Ida bed in open cut

the results of the investigation recorded herein cover all possible sources of iron, all ferruginous materials in the Clinton formation are considered and include, therefore, all beds of relatively high iron content.

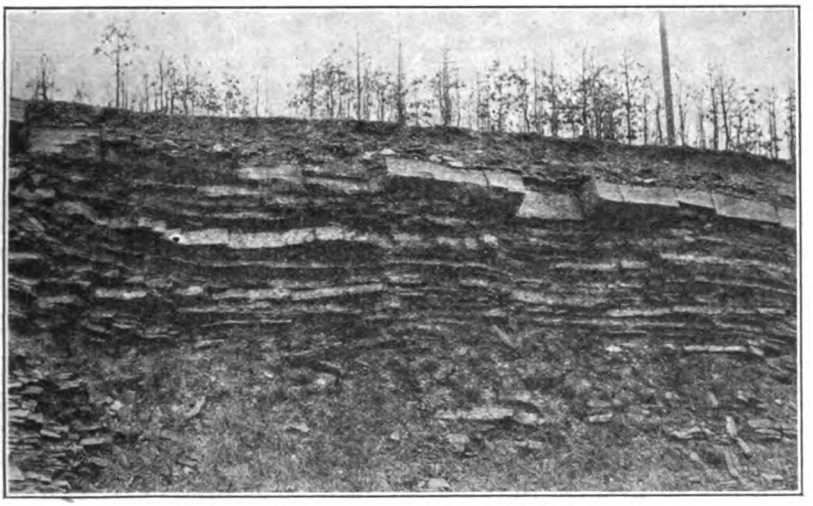

FIGURE 4.—Ida and Hickory Nut ore beds in old open cut

The so-called ore beds from above downward are the Ida, the Hickory Nut, the Big Seam, and the Irondale. The Ida and Hickory Nut beds are so close together that they probably represent benches of the same bed; some hold a like opinion of the Big Seam and the

[1] Burchard, E. F., and Butts, Charles. Iron Ores, Fuels, and Fluxes of the Birmingham District, Ala.: U. S. Geol. Survey Bull. 400, 1910, p. 14.

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Irondale, but facts presented in this paper appear, however, to disprove that contention. (See figs. 1 to 6.)

The beds of ferruginous sandstone between the Hickory Nut bed and the Big Seam and above the Ida bed are thick and in certain places have a surprisingly high iron content; if it were possible to mine and utilize this sandstone as well as ore from the four beds mentioned, the materials available for iron making in the district would be greatly augmented. (See fig. 6.)

The ore beds and the accompanying beds of sandstone and shale have been disturbed and warped by folding, and secondary folding has

FIGURE 5.—Big Seam in open cut showing how slope of surface conforms to dip of bed

seriously complicated the occurrence of the ore. The dip in the north part of the district is about 16°, but to the south dips of 35° are not uncommon.

EXTENT AND THICKNESS OF ORE BEDS

The Big Seam is 15 to 22 feet thick, about 18 feet being the average thickness. It is separated into two parts or benches by "slate" that ranges from a knife edge to 30 inches in thickness; the upper bench has an average thickness of 10 feet, but the lower is 8 feet, where it is of workable grade. (See figs. 5 and 7 to 11.)

The thickness of the other ore beds is as follows: Ida, 2 feet 9 inches, with a maximum thickness of 5 feet; Hickory Nut, 2 feet 6 inches, with a maximum thickness of 4 feet; Irondale, about 4 feet on the average, where worked, but attaining a thickness of 6 feet and more.

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The Big Seam has been mined on the surface and underground for over 20 miles along Red Mountain; the present underground workings cover a distance parallel with the outcrop of about 15 miles; it is the chief and much of the time the sole producer of red ore. (See fig. 11.)

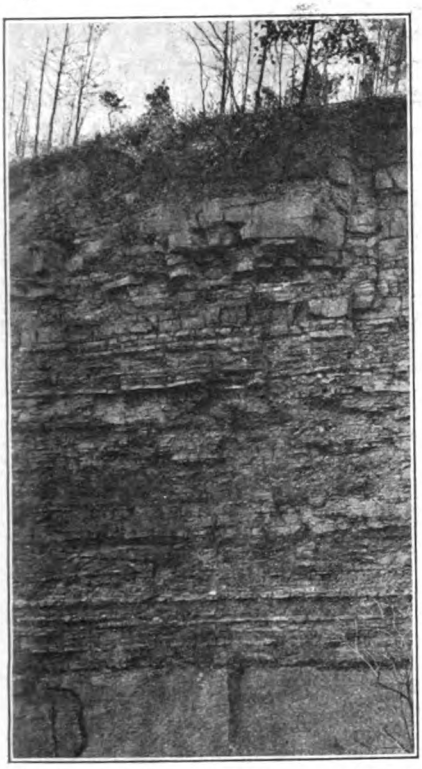

FIGURE 6.—Section showing Ida and Hickory Nut beds, ferruginous sandstone, and part of Big Seam

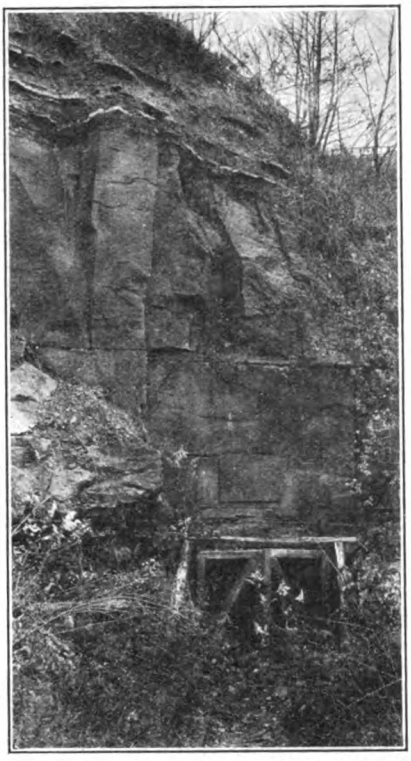

FIGURE 7.—Big Seam at portal of Helen-Bess mine

The Irondale bed is next to the Big Seam in importance and is worked in a small way for about 6 miles. The Ida was formerly worked both by open cut and underground at several points between Birmingham and Bessemer. The Hickory Nut has never been mined.

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FIGURE 8.—Twenty feet of Big Seam in Clinton mine

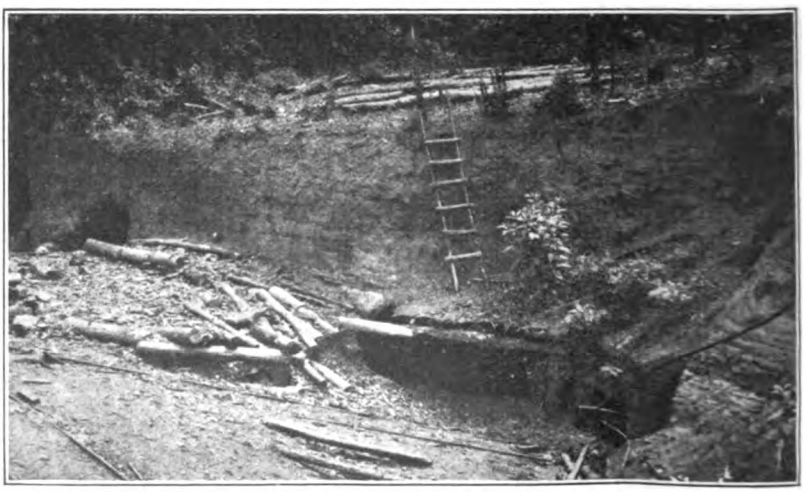

FIGURE 9.—Big Seam, showing low-grade sandy ore

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CHARACTER OF THE ORES

There are two general types of red iron ore, fossiliferous and oölitic. Although these types are distinct in themselves it is not uncommon for them to be present in the Big Seam at the same locality. The former type is composed largely of marine fossils surrounded by layers of iron oxide, the whole mass being cemented together by material of the same character. (See fig. 12.) The oölitic ore differes from the fossiliferous mainly in that rounded grains of silica take the place of the fossils, the iron oxide serving

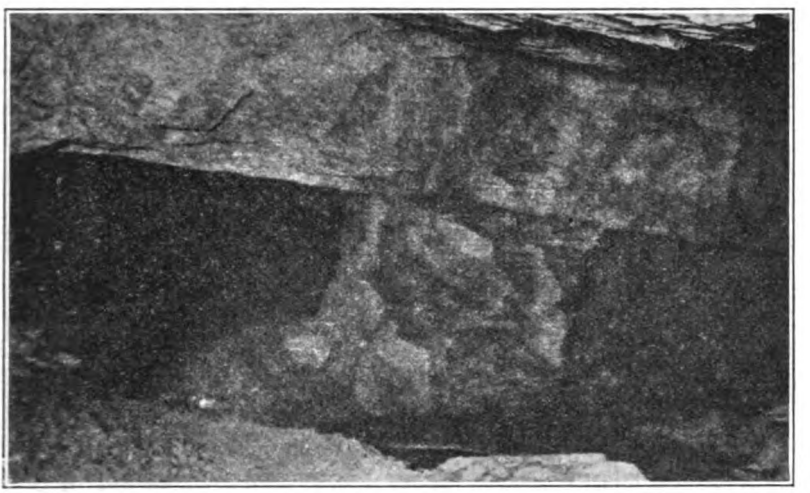

FIGURE 10.—Upper and lower benches of Big Seam shown in mine workings

both as a covering to the sand grains and as a bond, forming a ferruginous sandstone. (See fig. 13.)

Special types of ore, such as hard, semihard, and soft, have been produced by changes that have occurred since deposition. The ore bed has lost much of its lime content by the leaching action of percolating waters; this action has extended down the dip from the outcrop for a distance averaging 300 feet, but the limit of leaching is very irregular, and the maximum distance is 500 feet or more. The leached ores are commonly called "soft" or "semihard," whereas the unleached is known as "hard" ore. The effect of the leaching has been to increase the iron and silica content by the removal of lime, thus making what were formerly highly siliceous ores even more siliceous.

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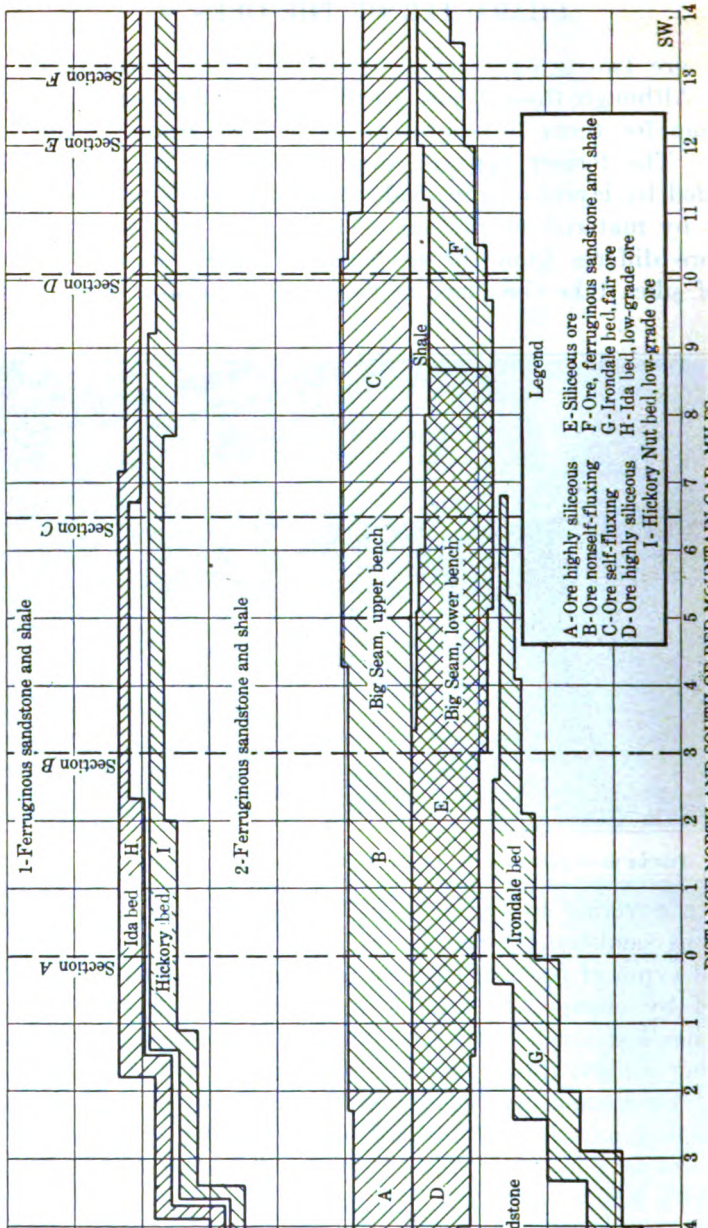

FIGURE 11.—Diagram showing the relation between the ore beds, both longitudinally and vertically, along Red Mountain, Birmingham district, Alabama

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FIGURE 12.—Fossiliferous ore

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FIGURE 13.—Oölitic ore

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PHYSICAL PROPERTIES

Samples of ores, from which the specific gravity and porosity were determined, were taken at the operating mines throughout the district. The average true and the apparent specific gravities of the ores are 3.61 and 3.48, and the average porosity is 3.48. (See Table 1

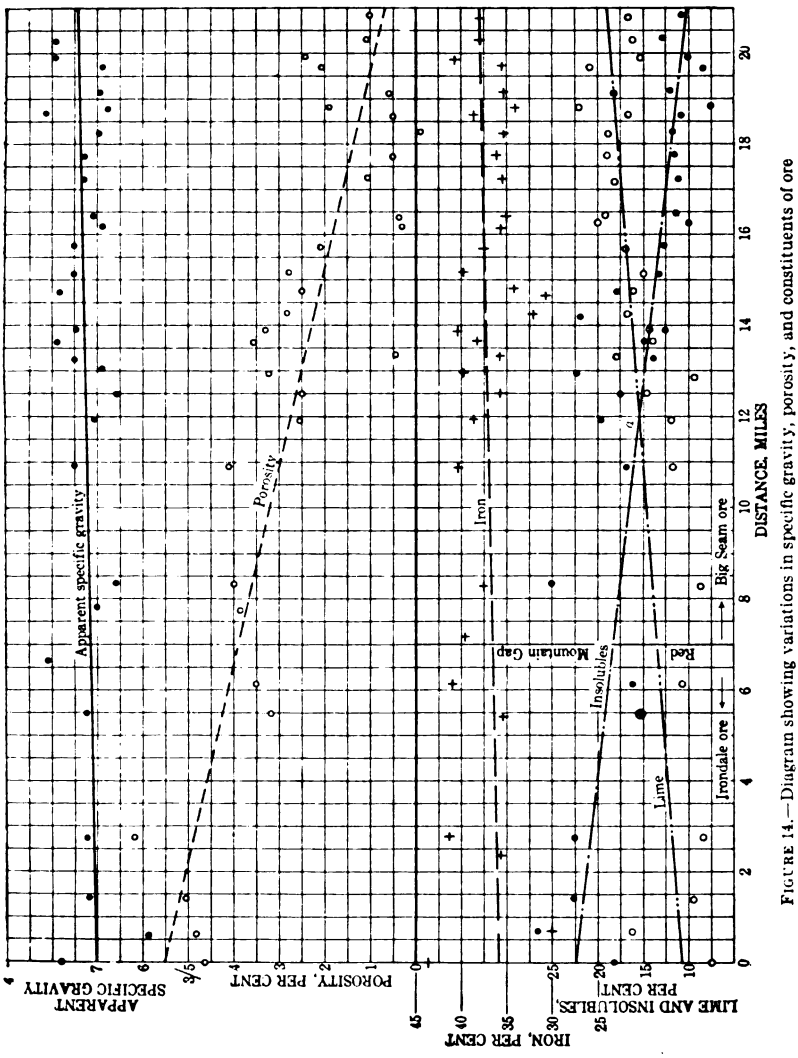

FIGURE 14.—Diagram showing variations in specific gravity, porosity, and constituents of ore

and fig. 14.) The specific gravity increases but the porosity decreases from the north to the south. The same series of samples was analyzed, the constituents of the ore being plotted at the bottom of Figure 14. The specific gravity evidently varies directly with the iron and to a less extent with the lime, but the porosity varies with the insolubles—that is, the silica and alumina.

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TABLE 1.—*True and apparent specific gravity and porosity of iron ores*

Sample No.	True specific gravity	Apparent specific gravity	Porosity, per cent	Sample No.	True specific gravity	Apparent specific gravity	Porosity, per cent
1	3.81	3.73	2.04	16	3.57	3.43	3.89
2	3.41	3.34	2.11	17	3.74	3.58	4.42
3	3.49	3.35	3.83	18	3.51	3.33	4.76
4	3.53	3.43	3.15	19	3.09	3.05	1.45
5	3.57	3.51	1.61	20	3.71	3.55	4.31
6	3.63	3.52	2.93	21	3.89	3.75	3.53
7	3.74	3.69	1.51	22	3.75	3.58	3.61
8	3.21	3.18	.94	23	3.69	3.64	3.18
9	3.50	3.44	1.63	24	4.01	3.82	4.98
10	3.72	3.65	2.01	25	3.47	3.31	4.45
11	3.41	3.37	1.50	26	3.53	3.36	4.24
12	3.59	3.53	1.37	27	3.85	3.53	7.13
13	3.54	3.43	3.14	28	3.74	3.52	6.02
14	3.82	3.67	3.77	29	3.37	3.18	5.76
15	3.59	3.47	3.52	30	3.90	3.68	5.71
				Average	3.61	3.48	3.48

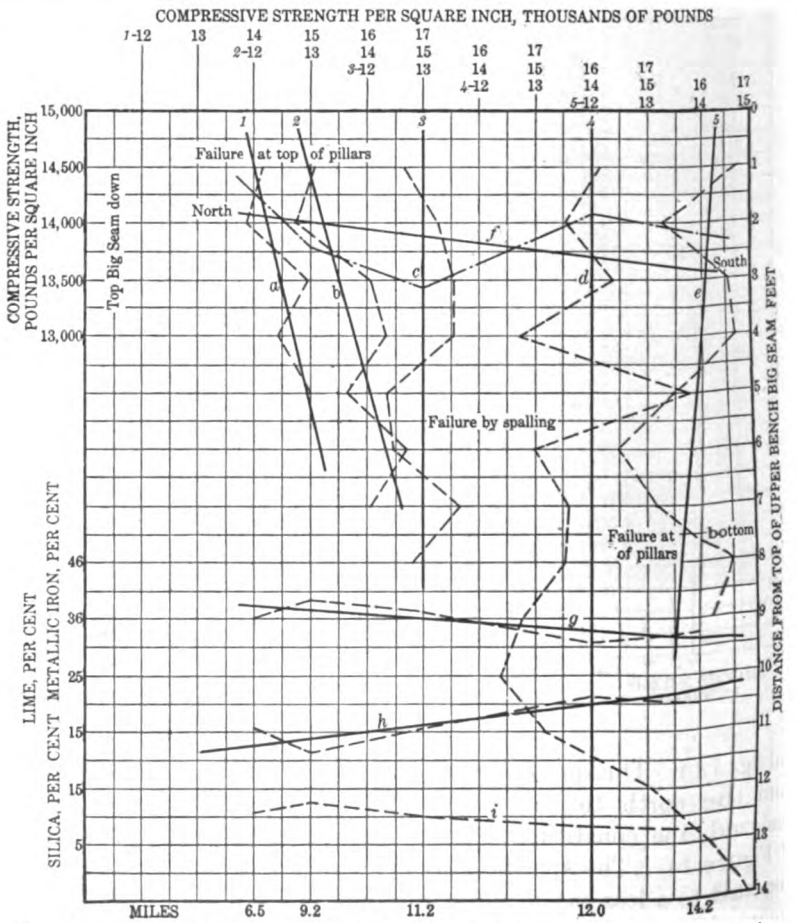

FIGURE 15.—Variations of compressive strength at intervals of approximately 2 miles, beginning 6½ miles south of Red Mountain Gap and going south

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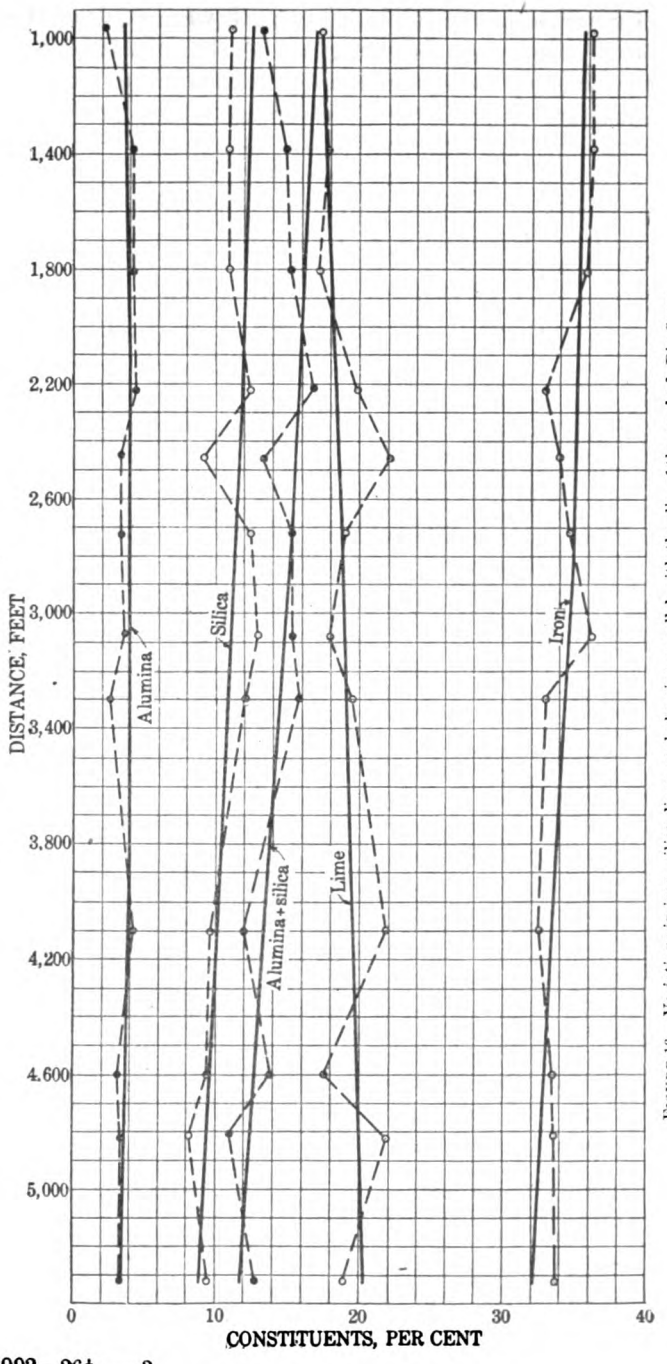

FIGURE 16.—Variations in iron, silica, lime, and alumina parallel with the dip of the ore bed, Big Seam

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Tests of compressive or crushing strength were made at the Bureau of Standards laboratory, Washington, D. C., of 110 cubes of iron ore, representing the thickness of the ore bed worked, which averaged 13,864 pounds per square inch. The strength of the ore as determined from the tests is shown in Figure 15.

Analyses of the crushed cubes are also plotted at the bottom of Figure 15, which shows that the compressive strength varies directly with the iron and silica content of the ore.[2]

CHEMICAL CONSTITUENTS

There is slight difference in the grade of the ore either parallel with the outcrop or with the dip of the ore bed. Figure 14 indicates a variation in iron of about 2 per cent throughout the district, increasing from the north to the south. Figure 16 and Table 2 show the variation of iron content parallel with the dip of the ore bed. The variation as noted here is a decrease on the dip of 2.5 per cent for 4,400 feet, or 0.05 per cent per 100 feet. All samples were taken in hard or unleached ore.

TABLE 2.—*Analyses of unleached ore of Big Seam in southern part of district*

Sample No., feet [a]	Constituents, per cent						
	Fe	SiO_4	Al_2O_3	CaO	MgO	P	S
1	36.25	10.90	2.40	17.4	0.38	0.28	None.
2	36.35	10.85	4.20	18.0	.42	.33	None.
3	35.90	11.30	4.10	17.3	.39	.30	None.
4	32.95	12.33	4.30	19.7	.35	.29	None.
5	34.15	9.05	3.10	20.4	.42	.25	None.
6	34.45	12.27	3.30	18.9	.40	.28	None.
7	36.35	12.12	3.20	18.0	.48	.27	None.
8	33.05	12.20	3.50	9.5	.43	.22	None.
9	32.35	9.62	2.10	21.7	.18	.23	None.
10	33.65	9.41	4.45	17.5	.31	.26	None.
11	35.60	8.13	2.80	21.8	.21	.24	None.
12	33.45	9.48	3.20	19.0	.34	.26	None.
Average	34.36	10.63	3.38	19.10	.33	.26	

[a] At approximately 500-foot intervals on the dip.

The results of other samplings at intervals of 1 to 2 miles north of those shown in Table 2 and Figure 16, which cover the southern part of the district, are given in Table 3.

[2] Crane, W. R., "Roof support in the red iron ore mines of the Birmingham district": Trans. Am. Inst. Min. and Met. Eng., Birmingham meeting, 1924, 39 pp.

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TABLE 3.—*Analyses of unleached ore of Big Seam in north central part of district*

Sample No., feet [a]	Constituents, per cent						
	Fe	SiO_2	Al_2O_3	CaO	MgO	P	S
1	36.04	9.85	2.60	18.64	0.52	0.301	None.
2	37.78	9.30	2.62	17.53	.51	.305	None.
3	37.02	9.35	2.70	18.40	.54	.287	None.
4	34.38	9.43	2.74	20.23	.58	.295	None.
5	36.04	9.78	2.76	18.42	.51	.282	None.
6	36.42	9.45	2.97	18.17	.62	.276	None.
7	37.02	10.60	2.72	17.36	.49	.296	None.
Average	36.38	9.68	2.73	18.39	.53	.291	
1	36.25	9.96	2.16	17.66	.15	.32	None.
2	39.75	10.60	2.84	13.85	.11	.35	None.
3	36.70	12.48	2.85	15.78	.21	.29	None.
4	36.15	9.70	2.34	17.16	.27	.32	None.
5	36.15	9.80	2.70	17.88	Trace.	.31	None.
6	31.30	25.00	5.91	11.31	Trace.	.33	None.
7	36.70	11.48	2.81	16.56	Trace.	.29	None.
Average	36.14	12.71	3.08	15.74	.....	.31	
.....	35.05	9.40	2.58	19.76	(b)	.30	None.
2	34.85	11.76	2.93	18.76	(b)	.32	None.
3	38.20	10.98	2.96	16.10	(b)	.34	None.
4	35.70	11.52	2.89	18.32	(b)	.33	None.
5	36.00	10.62	2.67	17.96	(b)	.33	None.
6	36.35	8.32	2.62	18.98	(b)	.29	None.
7	34.90	8.80	2.55	19.04	(b)	.30	None.
8	35.35	9.66	2.81	18.38	(b)	.29	None.
9	41.30	12.56	2.91	13.20	(b)	.32	None.
Average	36.41	10.40	2.76	17.80	.....	.313	

[a] At approximately 500-foot intervals on the dip.

[b] 0.3 or less.

In order to determine the variations in the character of the ore through weathering a series of 30 samples was taken at 2-inch intervals along the face of a pillar and parallel with the strike of the ore bed. (See Table 4.) The results are interesting in that they show the effect of cross bedding on the concentrations of lime and the effect of leaching along joint or "slip" planes. The remarkably uniform grade of the ore along the strike is also shown to advantage.

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TABLE 4.—*Analyses of hard ore in Big Seam*

Sample No.[a]	Constituents, per cent						
	Moisture	Combined water	Free iron	Ferrous oxide	Ferric oxide	CaO combined	CaO free
1	0.72	1.11	0.35	1.48	60.77	7.00	Trace.
2	.73	1.06	.30	1.48	59.75	7.75	Trace.
3	.48	1.09	.18	1.38	55.36	14.95	None.
4	.53	1.06	.20	1.31	57.20	14.38	None.
5	.53	1.18	.15	1.45	53.37	16.40	None.
6	.26	1.05	.13	1.12	29.11	32.90	None.
7	.24	.95	.10	1.25	29.83	32.25	None.
8	.35	1.12	.13	1.38	41.55	25.25	None.
9	.53	1.07	.15	1.48	58.06	12.95	None.
10	.55	1.12	.18	1.44	56.36	13.85	None.
11	.37	1.02	.15	1.22	41.13	24.95	None.
12	.47	.98	.25	1.38	49.56	18.80	None.
13	.49	1.03	.19	1.28	47.86	10.90	None.
14	.51	.96	.15	1.35	56.38	14.85	None.
15	.43	1.04	.14	1.41	47.43	20.80	None.
16	.37	1.09	.17	1.28	44.39	22.25	None.
17	.41	1.03	.17	1.32	44.59	21.00	None.
18	.42	.98	.13	1.35	42.13	24.00	None.
19	.52	1.09	.18	1.48	54.70	15.85	None.
20	.51	1.01	.18	1.28	56.13	15.05	None.
21	.56	.95	.17	1.41	60.57	12.05	None.
22	.51	1.02	.18	1.52	59.30	12.65	None.
23	.47	1.04	.25	1.41	57.20	14.55	None.
24	.53	1.06	.17	1.35	59.00	13.75	None.
25	.57	1.03	.25	1.25	55.90	14.20	None.
26	.54	1.00	.20	1.50	51.12	17.50	None.
27	.49	1.05	.15	1.41	49.45	18.25	None.
28	.50	.98	.20	1.48	50.10	18.10	None.
29	.50	1.01	.18	1.35	51.23	17.60	None.
30	.48	1.03	.15	1.44	49.20	18.50	None.
Average	.48	1.04	.18	1.37	50.28	17.44	

Sample No.[a]	Constituents, per cent—Continued							
	CO_2	Combined MgO	P	S	Al_2O_3	SiO_2	Total iron	Total
1	5.82	0.36	0.40	0.008	2.47	16.53	44.00	96.91
2	6.53	.36	.33	.008	2.49	16.00	43.23	96.78
3	12.01	.34	.35	.009	2.42	7.69	39.97	96.23
4	11.16	.28	.36	.008	2.72	8.52	41.22	97.72
5	13.85	.37	.28	.011	2.28	7.06	38.60	97.28
6	26.89	.41	.16	.013	1.30	3.73	20.36	97.06
7	26.01	.35	.17	.010	1.28	4.24	21.93	96.66
8	20.43	.33	.21	.012	1.71	4.69	30.26	97.17
9	11.07	.32	.37	.010	2.80	8.12	41.90	96.92
10	11.34	.27	.34	.010	2.72	8.25	40.71	96.42
11	19.91	.41	.25	.008	2.05	5.68	29.86	97.14
12	14.83	.35	.32	.008	2.76	8.54	35.98	98.24
13	15.06	.34	.37	.008	2.25	8.74	34.67	96.51
14	11.90	.37	.32	.008	2.44	7.76	40.63	96.99
15	16.38	.41	.27	.007	2.35	7.17	34.41	97.83
16	17.80	.40	.29	.010	2.15	7.27	32.21	97.46
17	17.02	.39	.30	.011	2.00	8.41	32.38	96.64
18	19.20	.40	.26	.011	1.77	7.13	30.64	97.77
19	12.26	.41	.37	.010	1.84	8.28	39.58	96.98
20	11.48	.43	.35	.010	1.95	8.16	40.43	96.53
21	9.87	.42	.34	.008	3.16	8.18	43.63	97.68
22	10.10	.38	.35	.010	3.10	8.22	42.83	97.33
23	11.17	.36	.35	.009	2.95	8.14	41.35	97.89
24	10.40	.39	.36	.008	3.15	7.37	42.50	97.55
25	11.60	.42	.34	.009	2.95	8.33	40.31	96.84
26	14.19	.40	.31	.010	2.65	8.13	37.12	97.54
27	14.98	.44	.32	.010	2.52	8.40	35.83	97.47
28	14.52	.36	.32	.009	2.81	8.20	36.39	97.57
29	13.67	.38	.37	.009	2.82	8.70	37.05	97.80
30	15.01	.36	.34	.010	2.13	8.13	35.67	96.77
Average	14.21	.37	.31	.009	2.39	8.12	36.85	97.81

[a] Samples taken at intervals of 2 inches along face of pillar parallel with strike.

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GRADE OF HARD ORE IN BEDS

The grade of the ore in the respective beds is given in the tables that follow. The samples represent consecutive feet from the top of the beds down.

Big Seam.—Analyses of the hard ore in the upper bench of the Big Seam for various thicknesses worked and at intervals of approximately 2 miles from the south to the north, in the active parts of the district, appear in Table 5.

TABLE 5.—*Analyses of hard ore in upper bench, Big Seam*

Sample No., feet	Constituents, per cent				Sample No., feet	Constituents, per cent			
	Fe	SiO_2	Al_2O_3	CaO		Fe	SiO_2	Al_2O_3	CaO
1	27.5	10.5	2.6	22.7	1	41.0	13.4	2.4	11.7
2	24.7	6.6	2.5	27.7	2	35.6	8.0	2.5	19.1
3	35.0	9.3	2.3	17.9	3	31.8	14.5	2.3	18.7
4	36.2	9.9	3.0	16.1	4	34.5	7.0	2.6	18.9
5	38.8	7.2	3.2	14.8	5	41.8	13.4	2.0	10.2
6	33.3	7.6	2.5	18.9	6	35.2	9.1	2.2	17.0
7	26.5	5.1	2.4	27.6	7	38.0	7.8	3.2	16.4
8	36.5	9.9	2.4	15.0	8	39.7	10.2	2.7	13.5
9	36.4	5.0	2.7	18.5					
Average	32.7	7.9	2.6	19.9	Average	37.2	10.4	2.4	15.6
1	39.0	14.4	4.0	10.7	1	33.2	12.6	2.3	16.4
2	29.6	5.5	2.2	24.6	2	26.3	12.9	3.0	19.5
3	34.3	8.0	1.9	18.1	3	41.9	16.4	2.2	6.9
4	28.8	8.5	1.9	20.7	4	46.9	15.3	1.6	5.6
5	41.5	6.9	2.1	12.6	5	43.6	11.2	2.6	9.2
6	20.3	6.5	1.6	32.0	6	47.5	12.4	2.3	6.9
7	22.6	8.8	1.7	28.0	7	35.4	9.4	2.0	16.9
8	8.3	3.4	1.6	44.9	Average	39.2	12.8	2.2	11.6
9	35.3	10.9	2.6	17.5					
10	35.5	9.9	2.3	16.6	1	31.9	7.0	2.0	21.4
11	34.2	7.2	2.1	19.4	2	43.7	13.8	2.1	7.2
12	37.5	9.3	2.4	15.5	3	44.3	11.7	2.8	9.5
13	31.8	9.0	2.4	19.7	4	34.5	10.9	2.5	17.5
14	35.4	10.4	3.2	16.3	5	27.4	11.2	1.9	23.0
Average	31.0	8.4	2.2	21.1	Average	36.3	10.9	2.2	15.7
					Grand average	34.4	9.7	2.3	17.7

The average iron content of the ores mined at present is 35.84 per cent. Their composition follows: Iron, 34.36 to 36.41 per cent; lime, 15.74 to 19.10 per cent; silica, 9.68 to 12.78 per cent; alumina, 2.75 to 3.38 per cent; and phosphorus, 0.267 to 0.325 per cent. The ores contain practically no sulphur.

Irondale bed.—The Irondale bed has been worked in recent years at three or four mines in the north part of the district. Table 6 gives analyses of the ore at the most southern point worked.

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TABLE 6.—*Analyses of hard ore in Irondale bed*

Sample No., feet	Constituents, per cent						
	Fe	SiO_2	Al_2O_3	CaO	MgO	P	S
1	20.76	64.25	3.31	0.23	0.18	0.032	0.06
2	31.96	36.30	2.49	7.64	.27	.319	.06
3	25.66	44.40	3.22	8.03	.34	.204	.03
4	24.26	19.45	3.54	22.16	.42	.204	.03
5	27.45	20.45	4.50	18.12	.68	.211	.05
6	29.39	18.45	5.44	17.13	.56	.216	.04
7	28.61	23.80	8.46	12.69	.92	.197	.04
Average	26.87	32.44	4.42	12.28	.48	.191	.04

As no hard ore has been mined from the Ida and Hickory Nut beds, the analyses are given below.

GRADE OF SOFT ORE IN BEDS

In the early days of mining in the Birmingham district, only soft ore was mined, for practice in pig-iron manufacture had not been adapted to the ores containing much lime. A large part of the soft ores of the upper bench of the Big Seam was removed by open cuts, but with the change in iron manufacture, mining of the soft ores was stopped and a large tonnage still remains. As these ores have potential value as a source of iron, their availability was investigated.

Detailed analyses of the Ida and Hickory Nut beds are given, followed by analyses of the soft ores of all ore beds.

Ida bed.—At present there are no active workings in the Ida bed and therefore no production from it. Table 7 shows analyses of a typical ore from this bed.

TABLE 7.—*Analyses of soft ore in Ida bed*

Sample No., feet	Constituents, per cent						
	Fe	SiO_2	Al_2O_3	CaO	MgO	P	S
1	35.60	40.13	4.58	0.70	Trace.	0.17	None.
2	46.30	27.36	3.50	.60	Trace.	.15	None.
3	44.50	29.69	3.81	.65	Trace.	.13	None.
Average	42.13	32.36	3.99	.65	----------	.15	--------

Hickory Nut bed.—As no ore is mined from the Hickory Nut bed at present or in fact has ever been mined except in connection with the Ida bed, only soft ores are available for sampling and analysis. Table 8 gives typical analyses of the ores of the Hickory Nut bed.

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TABLE 8.—*Analyses of soft ore in Hickory Nut bed*

Sample No., feet	Constituents, per cent						
	Fe	SiO_2	Al_2O_3	CaO	MgO	P	S
1	36.50	41.40	4.12	None.	None.	0.02	None.
2	40.90	35.30	3.86	None.	None.	.02	None.
3	41.40	34.80	3.72	None.	None.	.02	None.
Average	39.60	37.10	3.90			.02	

GRADE OF ORE IN ALL BEDS

Extended sampling of the ore beds exposed in the old open-cut workings has made possible presentation of a large amount of data relative to the grade of the soft or leached ore. The following analyses of the ores are grouped by beds, the locality being designated in miles and tenths from a point 7 miles north of Red Mountain Gap; they cover a distance of 20 miles along the outcrop. The figures represent average analyses and cover the full thickness of the beds mentioned. (See Table 9.)

TABLE 9.—*Analyses of leached iron ores from ore beds, Red Mountain*

1. ANALYSES OF SAMPLES TAKEN FROM UPPER BENCH, BIG SEAM

Location, miles	Constituents, per cent				
	Fe	SiO_2	Al_2O_3	CaO	$SiO_2+Al_2O_3$
0–.0–0	36.15	40.56	4.46	0.70	45.02
4–.5–5	33.02	45.18	3.25	1.30	48.43
5–.5–6	38.78	35.89	3.23	3.37	39.12
5–.6–6	36.61	28.22	2.84	8.37	31.06
6–.4–7	33.85	44.71	4.05	.083	48.76
7–.4–8	40.83	29.50	3.04	4.23	32.54
7–.5–8	37.75	28.36	2.50	7.18	20.86
8–.4–9	36.73	22.67	2.61	11.08	25.28
9–.3–10	46.24	21.68	3.37	3.38	25.05
10–.5–11	50.13	20.29	3.69	.29	23.98
11–.6–12	37.69	14.61	2.49	14.19	17.10
12–.1–13	40.03	14.91	2.33	12.14	17.24
14–.1–15	42.43	12.62	2.57	12.75	15.19
17–.2–18	53.93	15.08	3.45	Trace.	18.53
18–.5–19	51.97	14.33	3.63	3.13	17.96
Average	41.07	25.90	3.16	5.87	28.40

2. ANALYSES OF SAMPLES TAKEN FROM LOWER BENCH, BIG SEAM

4–.5–5	28.54	48.45	3.57	2.56	52.02
5–.5–6	27.49	41.49	3.46	7.20	44.95
5–.6–6	29.77	45.20	3.53	4.67	46.73
6–.4–7	43.86	31.41	3.62	.07	35.03
7–.4–8	32.57	32.33	2.71	9.35	35.04
7–.5–8	33.04	30.81	1.27	9.48	32.08
8–.4–9	29.63	32.97	3.32	10.50	36.29
10–.5–11	41.30	32.26	3.66	.80	35.92
11–.6–12	33.03	25.76	2.62	11.76	28.38
12–.1–13	44.94	26.49	4.07	Trace.	30.56
14–.1–15	50.39	21.53	2.93	Trace.	24.46
Average	35.86	33.33	3.16	6.27	36.49

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TABLE 9.—*Analyses of leached iron ores from ore beds, Red Mountain*—Contd.

3. ANALYSES OF SAMPLES TAKEN FROM THE IRONDALE BED

Location, miles	Constituents, per cent				
	Fe	SiO_2	Al_2O_3	CaO	$SiO_2+Al_2O_3$
0-.0-0	36.30	20.39	3.74	11.36	24.13
5-.1-6	26.87	32.44	4.42	12.28	36.86
5-.5-6	29.83	42.49	5.97	2.12	48.46
6-.4-7	36.42	37.59	5.87	.08	43.46
7-.4-8	23.96	29.26	2.86	16.56	32.12
8-.4-9	25.99	28.10	3.40	15.75	31.50
Average	29.89	31.71	4.37	9.69	36.06

4. ANALYSES OF SAMPLES TAKEN FROM THE HICKORY NUT BED

4-.5-5	39.00	36.60	3.87	0.92	40.47
5-.5-6	36.11	41.47	4.10	.10	45.57
5-.6-6	39.22	39.96	4.22	.04	44.18
7-.5-8	24.70	58.80	3.87	None.	62.67
8-.4-9	34.10	45.70	4.01	None.	49.71
8-.6-9	39.60	37.10	3.56	None.	40.66
9-.0-0	38.20	40.80	3.00	None.	43.80
10-.5-11	41.10	34.84	4.35	None.	39.19
11-.6-12	37.60	38.96	4.27	None.	43.23
12-.1-13	35.00	43.27	3.43	None.	46.70
12-.5-13	35.55	43.53	2.63	Trace.	46.16
13-.8-14	42.80	33.40	3.01	Trace.	36.41
14-.5-15	27.15	55.66	3.24	None.	58.90
14-.9-15	31.60	49.30	3.88	None.	53.18
15-.9-16	17.45	69.90	3.82	None.	73.72
16-.9-17	25.75	54.17	5.10	None.	59.27
18-.9-19	29.70	51.25	2.56	None.	53.81
19-.4-20	26.90	55.16	3.14	None.	58.30
20-.6-21	27.25	54.17	4.83	None.	59.00
Average	33.09	46.52	3.73	----	50.25

5. ANALYSES OF SAMPLES TAKEN FROM THE IDA BED

0-.0-0	36.55	41.91	3.64	1.10	45.55
4-.5-5	42.75	33.65	3.01	None.	36.66
5-.5-6	40.57	36.87	3.23	.127	40.10
5-.6-6	35.59	42.64	4.15	.08	46.79
8-.4-9	43.30	33.40	3.65	None.	37.05
9-.0-0	41.40	35.00	3.42	None.	38.42
11-.1-12	45.50	27.62	3.06	None.	30.68
12-.1-13	44.30	28.64	3.57	None.	32.21
12-.5-13	44.05	30.98	3.37	Trace.	34.35
13-.9-14	42.80	33.40	3.01	Trace.	36.41
14-.5-15	38.20	39.73	3.95	None.	43.68
14-.9-15	40.50	37.15	3.13	None.	40.28
15-.9-16	39.00	38.60	3.64	None.	42.24
16-.9-17	42.15	32.39	3.96	.65	36.35
Average	41.18	35.14	3.48	----	38.62

FERRUGINOUS SANDSTONE

Analyses of certain ferruginous sandstones showed a surprisingly high iron content and led to extended investigation of all ferruginous materials in the Clinton formation to ascertain the thickness and extent of beds containing relatively high percentages of iron. Samples were taken for each foot of the ferruginous sandstone, beginning at the top and passing down through the sandstone and shales of the Clinton formation. The sections sampled include the four ore beds mentioned before, as well as the intermediate and overlying beds of sandstone.

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GRADE OF LEACHED ORE AND SANDSTONE

As it was fairly easy to sample the exposed face of open-cut workings and as the results indicate what may be expected in the leached rock, samples were first taken along the open cuts paralleling the outcrop and are recorded herein by sections.

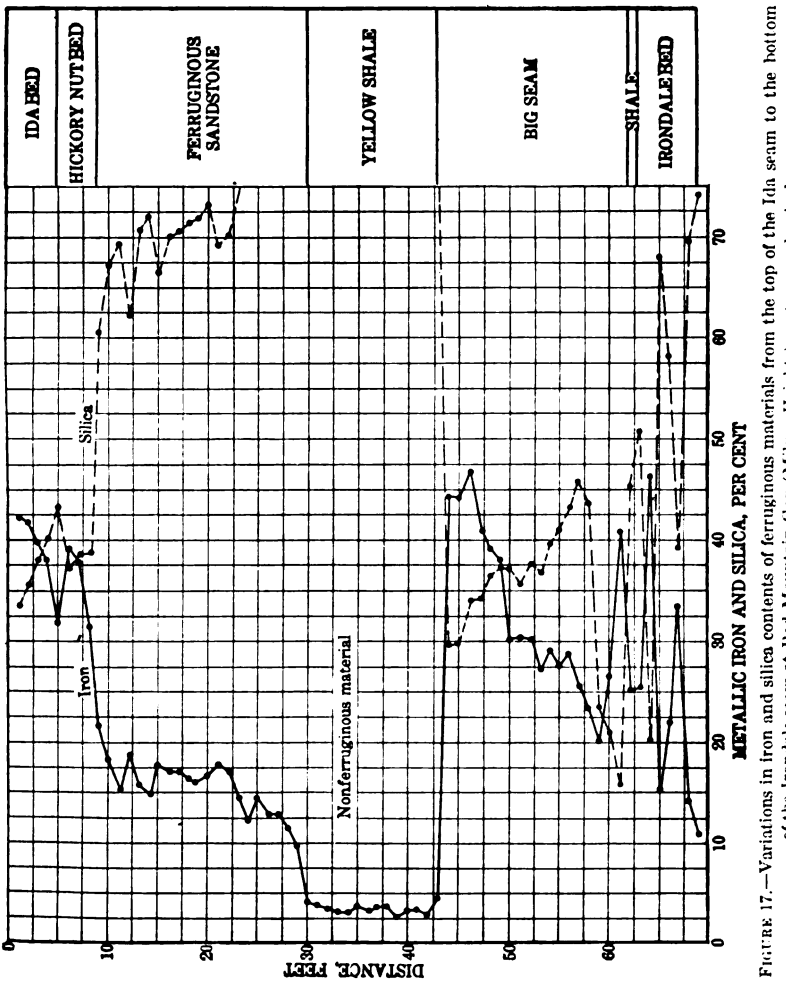

FIGURE 17.—Variations in iron and silica contents of ferruginous materials from the top of the Ida seam to the bottom of the Irondale seam at Red Mountain Gap (Milner Heights); outcrop or leached ores

Section A.—Section A was taken at Red Mountain Gap and is the point from which all other localities are reckoned in miles to the north or south. (See Table 10 and fig. 17.)

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TABLE 10.—*Analyses of samples of leached ore taken from top of Ida bed to bottom of Irondale bed, Red Mountain Gap* [a]

Sample No., feet	Constituents, per cent						
	Fe	SiO_2	Al_2O_3	CaO	MgO	P	S
1	42.31	33.57	3.83	0.132	0.138	0.033	None.
2	41.86	35.57	3.01	.208	.167	.050	0.01
3	39.90	38.20	3.06	.076	.109	.038	None.
4	38.23	40.15	3.03	.094	.138	.051	None.
5	31.74	43.30	7.24	.094	.362	.077	.01
Average	38.80	38.17	4.03	.120	.183	.049	.004
6	39.14	37.25	4.17	.076	.072	.104	None.
7	37.78	38.52	4.09	.094	.091	.078	None.
8	31.43	48.65	4.04	.132	.253	.055	None.
9	21.76	60.60	5.16	.151	.272	.047	None.
Average	32.52	46.25	4.36	.113	.172	.071	.....
10	18.51	67.27	3.39	.208	.123	.041	None.
11	15.34	71.80	3.28	.076	.138	.034	None.
12	18.74	62.40	6.69	.132	.224	.038	None.
13	15.94	70.80	3.77	.076	.145	.027	None.
14	14.73	72.20	3.96	.113	.152	.026	None.
15	17.98	66.60	5.15	.094	.181	.041	None.
16	17.23	70.10	2.65	.094	.162	.036	None.
17	17.23	70.62	2.30	.113	.152	.022	None.
18	16.62	71.50	2.85	.208	.127	.028	None.
19	16.17	73.00	2.51	.246	.098	.026	None.
20	15.87	73.35	2.13	.094	.152	.020	None.
21	17.98	69.40	2.73	.132	.127	.024	None.
22	17.23	70.25	2.96	.094	.152	.025	None.
Average	16.89	69.94	3.41	.129	.148	.029	.....
23	14.51	.....	.....	.....	.....	.....	.....
24	12.32	.....	.....	.....	.....	.....	.....
25	14.58	.....	.....	.....	.....	.....	.....
26	13.00	.....	.....	.....	.....	.....	.....
27	13.30	.....	.....	Shale.	.....	.....	.....
28	11.56	.....	.....	.....	.....	.....	.....
29	9.82	.....	.....	.....	.....	.....	.....
30	4.23	.....	.....	.....	.....	.....	.....
Average	11.66	.....	.....	.....	.....	.....	.....
31	3.85	.....	.....	.....	.....	.....	.....
32	3.63	.....	.....	.....	.....	.....	.....
33	3.32	.....	.....	.....	.....	.....	.....
34	3.32	.....	.....	.....	.....	.....	.....
35	3.93	.....	.....	.....	.....	.....	.....
36	3.48	.....	.....	.....	.....	.....	.....
37	3.55	.....	.....	.....	.....	.....	.....
38	3.70	.....	.....	Shale.	.....	.....	.....
39	2.64	.....	.....	.....	.....	.....	.....
40	3.32	.....	.....	.....	.....	.....	.....
41	3.48	.....	.....	.....	.....	.....	.....
42	3.02	.....	.....	.....	.....	.....	.....
43	4.61	.....	.....	.....	.....	.....	.....
Average	3.52	.....	.....	.....	.....	.....	.....
44	44.43	29.78	3.85	.756	.128	.121	.05
45	44.28	29.90	3.66	.416	.116	.191	None.
46	41.94	34.05	3.12	.132	.062	.110	.01
47	40.80	34.22	3.04	.831	.105	.314	.02
48	39.22	36.65	3.32	.982	.098	.315	None.
49	38.23	37.50	3.68	1.280	.105	.343	None.
50	30.15	37.20	3.22	8.290	.128	.358	.02
51	30.38	35.75	3.01	8.710	.188	.316	.02
52	30.22	37.90	3.12	7.740	.188	.291	.07
53	27.28	36.90	2.72	10.840	.128	.263	.07
54	29.24	39.65	3.54	7.080	.159	.289	.06
55	27.73	41.00	3.21	7.590	.224	.222	.06
56	28.86	43.40	2.98	5.740	.145	.192	.07
57	25.69	45.85	3.45	6.670	.206	.237	.07
58	23.42	43.75	5.23	4.740	.452	.175	.07
59	20.10	23.70	3.91	22.990	.373	.166	.07
60	26.60	21.05	4.75	19.020	.481	.188	.07

[a] Analyses made by the University of Minnesota, Minnesota School of Mines experiment station, Minneapolis, Minn.

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TABLE 10.—*Analyses of samples of leached ore taken from top of Ida bed to bottom of Irondale bed, Red Mountain Gap*—Continued

Sample No., feet	Constituents, per cent						
	Fe	SiO_2	Al_2O_3	CaO	MgO	P	S
61	40.65	15.80	3.33	8.510	0.181	0.268	0.05
62	25.39	45.23	8.08	2.280	.547	.181	.06
Average	32.34	35.22	3.74	6.557	.211	.238	.05
63	25.54	50.66	5.73	1.240	.344	.148	None.
64	46.24	20.20	5.65	1.960	.199	.244	None.
65	15.49	68.10	5.34	.403	.253	.087	None.
66	22.06	58.23	6.20	.236	.272	.103	None.
67	33.47	39.24	7.47	.236	.369	.114	None.
68	14.21	69.96	4.92	.069	.272	.056	None.
69	10.81	74.46	5.28	.069	.297	.101	None.
Average	23.71	55.03	5.81	.495	.277	.117	.....
Grand average	21.23	48.65	4.04	2.741	.199	.132	.015

Section B.—Section B is 3 miles south of section A. (See Table 11.)

TABLE 11.—*Analyses of samples of leached ore taken at a point 3 miles south of Red Mountain Gap*

Sample No., feet	Constituents, per cent					Sample No., feet	Constituents, per cent				
	Fe	SiO_2	Al_2O_3	CaO	P		Fe	SiO_2	Al_2O_3	CaO	P
1	42.0	33.1	3.9	None.	Trace.	9	19.2	67.2	2.3	None.	Trace.
2	42.1	33.5	3.3	None.	None.	30	18.9	62.5	5.0	None.	None.
						31	12.1	69.5	9.1	None.	Trace.
Average	42.05	33.3	3.6	.....	.....	32	11.2	68.0	10.8	None.	Trace.
						33	7.8	67.7	13.2	None.	Trace.
3	37.0	40.4	3.6	None.	Trace.	34	15.9	71.4	2.2	None.	Trace.
4	36.6	40.2	4.7	None.	None.						
						Average	13.20	68.13	8.12	Trace.	Trace.
Average	36.8	40.3	4.15	.....	.....						
						35	42.15	22.80	3.39	5.48	0.330
5	39.2	38.9	3.0	None.	Trace.	36	34.60	10.30	2.08	19.40	.280
6	43.0	31.5	3.8	None.	None.	37	38.00	17.60	2.87	13.10	.340
						38	26.70	13.40	.80	25.30	.225
Average	41.10	35.20	3.4	.....	.....	39	38.80	20.60	2.13	10.70	.330
						40	35.30	26.90	2.38	10.30	.320
7	28.8	48.4	5.9	None.	None.	41	37.40	26.25	2.87	9.30	.320
8	27.0	49.9	4.7	None.	Trace.	42	36.00	29.60	2.59	8.65	.340
9	12.7	73.1	5.6	None.	Trace.	43	39.90	23.70	3.12	7.80	.340
10	8.3	74.4	9.5	None.	Trace.	44	37.30	26.90	3.01	6.90	.340
11	5.0	81.6	6.9	None.	Trace.	45	38.00	25.80	3.13	7.60	.320
12	8.6	76.9	7.1	None.	Trace.	46	36.70	28.30	3.03	8.45	.340
						47	37.20	28.60	2.63	8.00	.340
Average	15.06	67.38	6.61	.....	.....	48	30.70	30.20	2.34	11.80	.275
						49	30.50	32.40	2.68	10.55	.275
13	8.0	77.1	7.6	None.	Trace.	50	31.55	28.80	2.63	11.40	.310
14	8.1	78.8	4.7	None.	Trace.	51	27.95	37.45	3.28	9.20	.180
15	8.1	78.9	4.2	None.	Trace.	52	25.70	39.15	4.85	9.60	.225
16	17.3	66.4	3.5	None.	Trace.	53	23.85	34.20	4.84	13.00	.220
						54	25.40	31.60	3.57	14.70	.140
Average	10.37	75.30	5.0	.....	.....	55	38.40	36.75	2.90	8.30	.150
17	21.3	59.0	3.1	Trace.	Trace.	Average	33.43	27.20	2.91	10.93	.282
18	12.8	71.8	7.2	None.	Trace.						
19	18.4	65.3	3.8	None.	Trace.						
20	16.6	68.7	4.5	None.	Trace.	56	23.80	24.50	2.82	20.00	0.140
21	14.3	64.2	11.1	None.	Trace.	57	25.00	30.20	4.64	14.45	.180
22	11.8	68.8	9.8	None.	None.	58	27.95	25.70	3.24	15.60	.165
23	6.2	76.7	8.8	None.	Trace.	59	25.40	19.90	3.24	21.50	.150
24	12.2	67.6	10.0	None.	Trace.						
25	5.0	70.3	15.6	0.9	Trace.	Average	25.53	25.07	3.48	17.88	.158
26	7.4	71.8	12.6	.7	Trace.						
27	8.6	67.5	14.9	None.	0.06	Grand average	23.96	47.81	5.14	11.15	.255
28	18.0	68.5	2.3	None.	Trace.						

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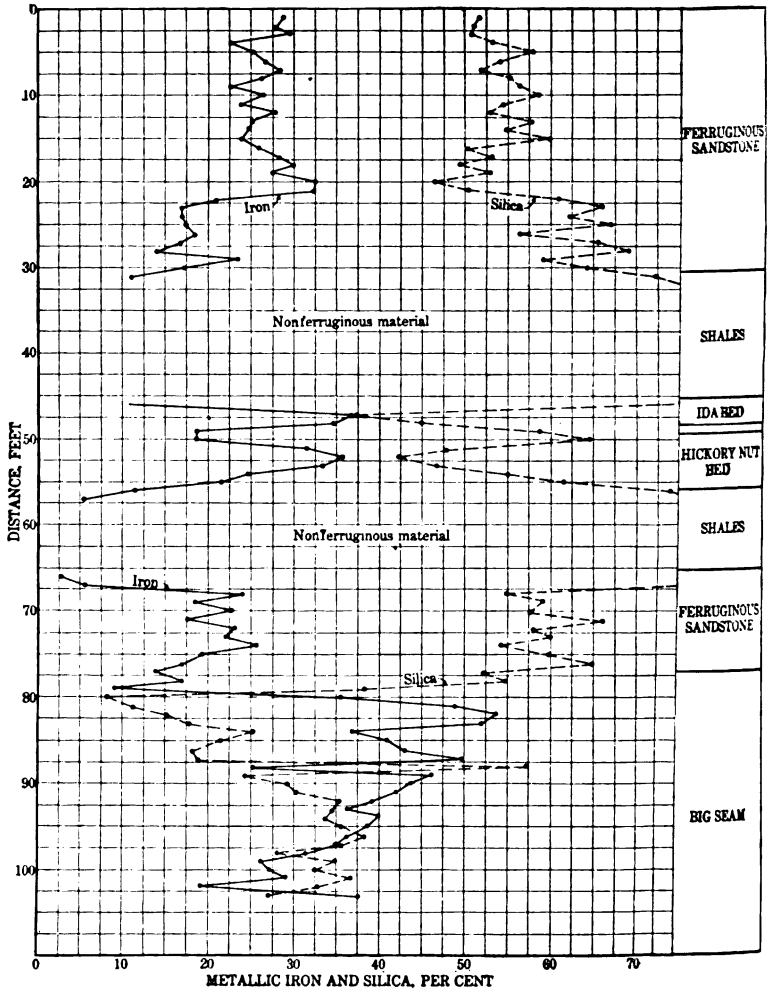

FIGURE 18.—Variations in iron and silica content of materials from the top of the Ida bed to and including part of the Irondale bed, 6½ miles south of Red Mountain Gap; outcrop or leached ore

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Section C.—Section C is 6½ miles south of section A. (See Table 12 and fig. 18.)

TABLE 12.—*Analyses of samples of leached ore taken at a point 6½ miles south of Red Mountain Gap*

Sample No., feet	Constituents, per cent					Sample No., feet	Constituents, per cent				
	Fe	SiO_2	Al_2O_3	CaO	P		Fe	SiO_2	Al_2O_3	CaO	P
1	29.0	51.8	3.6	None.	None.	69	18.6	59.2	6.8	None.	.02
2	27.9	51.2	5.0	None.	None.	70	22.7	57.6	4.8	None.	Trace.
3	29.6	50.8	4.0	None.	None.	71	17.5	66.0	5.2	None.	.05
4	22.7	53.4	7.8	None.	0.02	72	23.1	57.8	4.4	None.	Trace.
5	25.2	57.8	3.4	None.	None.	73	22.2	60.0	3.5	None.	.07
6	26.7	54.3	3.7	None.	.01	74	25.8	54.4	3.8	None.	.08
7	28.5	51.8	3.7	None.	.02	75	19.4	59.8	6.9	None.	Trace.
8	26.4	55.3	3.8	None.	Trace.	76	17.0	64.9	6.1	None.	Trace.
9	22.6	56.2	5.7	None.	None.	77	14.0	52.4	4.2	9.3	.06
10	26.5	53.6	4.2	None.	.02	78	16.9	54.7	3.7	7.1	.11
11	24.1	54.6	4.4	None.	None.						
12	27.8	52.9	4.2	None.	Trace.	Average	17.66	61.33	5.36		
13	25.1	57.8	3.5	None.	Trace.						
14	24.8	54.9	4.7	None.	Trace.	79	9.2	38.1	3.4	20.2	.04
15	24.0	59.8	3.1	None.	Trace.	80	35.5	8.3	3.0	16.3	.41
16	25.9	50.4	5.5	None.	None.	81	48.8	11.1	3.0	5.4	.39
17	28.4	53.1	3.1	None.	Trace.	82	53.5	15.1	2.6	None.	.41
18	30.0	49.6	4.1	None.	.02	83	52.0	17.7	3.5	.4	.16
19	27.6	52.9	4.0	None.	.02	84	36.8	25.1	6.2	5.8	Trace.
20	32.5	46.5	8.9	None.	.10	85	41.0	21.5	3.3	4.6	.41
21	32.4	50.5	4.0	None.	.06	86	42.8	18.3	3.5	4.9	.10
22	21.0	61.0	4.6	None.	Trace.	87	49.7	18.8	4.7	.7	.18
23	17.0	66.0	5.3	None.	None.	88	25.2	57.1	3.7	None.	None.
24	16.9	62.3	8.0	None.	Trace.	89	46.1	24.4	4.7	None.	.37
25	17.3	67.1	4.8	None.	Trace.	90	43.7	29.2	3.7	None.	.33
26	23.6	56.4	3.9	None.	Trace.						
27	16.9	65.5	5.2	None.	Trace.	Average	40.35	23.72	3.77		
28	14.2	69.2	6.0	None.	Trace.						
29	23.6	59.2	3.8	None.	Trace.	91	42.0	30.4	3.8	None.	Trace.
30	17.1	64.5	6.2	None.	Trace.	92	39.1	35.3	3.9	None.	Trace.
31 [a]	11.2	72.4	7.1	None.	None.	93	36.4	34.4	3.4	3.4	.28
						94	40.0	33.6	4.2	Trace.	.36
Average	24.1	56.9	4.8	None.	Trace.	95	38.6	35.5	3.8	None.	.14
						96	36.1	38.4	3.8	.4	.21
47	36.8	37.4	3.9	None.	Trace.	97	35.0	35.4	7.1	None.	.19
48	34.7	45.3	4.0	None.	Trace.	98	31.3	28.1	3.5	9.1	.07
49	18.7	58.7	3.8	None.	Trace.	99	26.0	34.9	5.9	7.5	.14
50	18.7	64.6	4.6	None.	None.	100	27.2	32.3	6.1	7.7	Trace.
51	31.5	47.9	4.9	None.	Trace.						
52	35.7	42.4	2.8	None.	Trace.	Average	35.17	33.83	4.55		
53	33.2	46.8	4.2	None.	Trace.						
54	24.8	55.0	5.1	None.	.02	101	29.1	36.7	5.0	4.7	.13
55	21.6	61.6	4.4	None.	None.	102	19.1	32.7	4.7	13.7	.05
56	11.5	74.1	4.1	None.	.03	103	37.6	27.0	5.9	2.9	.13
57 [b]	5.5	77.7	6.5	None.	Trace.						
						Average	28.60	32.13	5.20		
Average	24.8	55.6	4.39	None.	Trace.						
						Grand average	27.1	48.6	4.7	6.8	.06
66	2.8	78.8	7.3	None.	None.						
67	5.6	77.0	8.0	None.	Trace.						
68	24.0	54.8	5.1	None.	Trace.						

[a] Between samples 31 and 47 is 16 feet of shale.

[b] Between samples 57 and 66 is 9 feet of shale.

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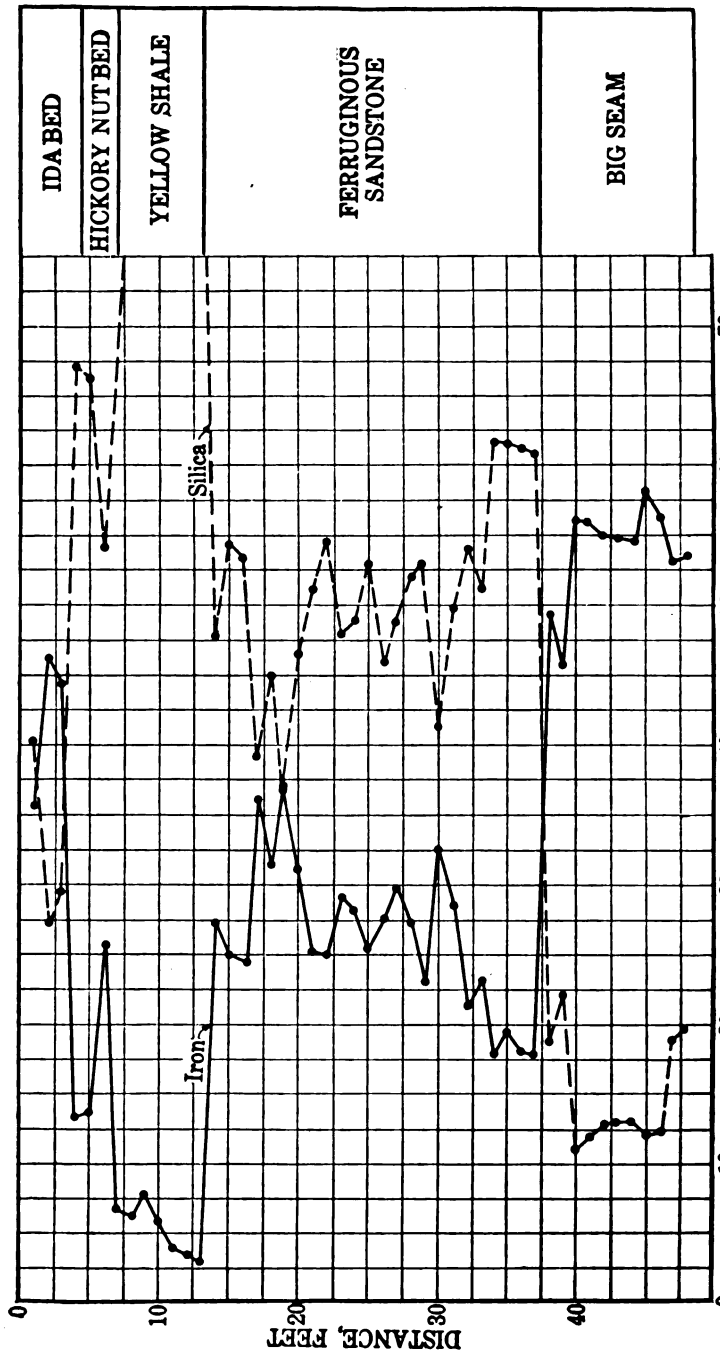

FIGURE 19.—Variations in iron and silica content of ferruginous materials from the top of the Ida bed to the bottom of Big Seam, 10½ miles south of Red Mountain Gap; outcrop or leached ore.

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Section D.—Section D is $10\frac{1}{10}$ miles south of section A. (See Table 13 and fig. 19.)

TABLE 13.—*Analyses of samples of leached ore taken from top of Ida bed to bottom of Big Seam at a point $10\frac{1}{10}$ miles south of Red Mountain Gap*

Sample No., feet	Constituents, per cent						
	Fe	SiO_2	Ae_2O_3	CaO	MgO	P	S
1	35.60	40.13	4.58	0.70	Trace.	0.17	None.
2	46.30	27.36	3.50	.60	Trace.	.15	None.
3	44.50	29.69	3.81	.65	Trace.	.13	None.
4	13.40	67.30	6.82	None.	None.	.08	None.
Average	34.95	41.12	4.67	.48	Trace.	.13	None.
5	13.70	66.49	7.34	None.	None.	.09	None.
6	25.75	54.17	5.10	None.	None.	.04	None.
Average	19.72	60.33	6.22	None.	None.	.07	None.
7	6.65						
8	6.25			Shale.			
9	7.95						
10	5.65			Shale.			
11	4.00						
12	3.60						
13	3.00						
Average	5.30						
14	27.50	47.65	7.88	Trace.	None.	.06	None.
15	25.05	54.46	5.16	Trace.	None.	.05	None.
16	24.60	53.40	6.66	Trace.	None.	.09	None.
17	36.15	39.40	5.46	None.	None.	.11	Trace.
18	31.40	45.05	6.26	.25	None.	.07	Trace.
19	36.90	37.00	5.71	.82	None.	.14	Trace.
20	31.15	46.50	4.53	Trace.	None.	.15	Trace.
21	25.15	51.10	7.54	Trace.	None.	.09	Trace.
22	25.00	54.70	5.18	.71	Trace.	.08	Trace.
23	29.25	48.00	4.09	1.89	Trace.	.15	Trace.
24	28.40	49.00	3.92	2.55	Trace.	.14	Trace.
25	25.45	52.80	5.33	.92	Trace.	.11	Trace.
26	27.70	46.10	7.75	3.01	Trace.	.11	Trace.
27	29.95	48.90	4.58	1.36	None.	.14	Trace.
28	27.35	52.10	4.77	.50	None.	.07	Trace.
29	23.00	53.00	7.76	.86	None.	.10	Trace.
30	32.50	41.40	4.78	2.63	Trace.	.12	Trace.
31	28.65	49.95	1.36	1.36	None.	.12	Trace.
32	21.30	34.10	7.83	.86	None.	.10	Trace.
Average	28.23	47.61	5.60	.93	Trace.	.14	Trace.
33	23.30	51.30	8.66	0.61	None.	.07	Trace.
34	18.10	61.70	6.43	.96	None.	.11	Trace.
35	19.50	61.70	3.66	2.83	Trace.	.09	Trace.
36	18.20	61.50	3.55	1.98	Trace.	Trace.	Trace.
37	18.15	60.90	4.08	1.45	Trace.	Trace.	Trace.
Average	19.45	59.42	5.07	1.56	Trace.	.05	Trace.
38	49.10	18.95	3.73	Trace.	None.	.06	None.
39	45.70	22.14	6.84	Trace.	None.	.04	None.
40	56.20	10.99	4.63	Trace.	None.	.03	None.
41	56.10	11.59	2.82	Trace.	None.	.05	None.
42	55.00	12.77	5.15	Trace.	None.	.04	None.
43	54.70	12.97	3.96	Trace.	None.	.04	None.
44	54.70	13.14	1.29	Trace.	None.	.04	None.
45	58.30	12.12	2.91	Trace.	None.	.02	None.
46	56.30	12.41	1.35	Trace.	None.	.05	None
47	53.20	19.07	2.65	Trace.	None.	.05	None.
48	53.70	19.74	2.68	Trace.	None.	.06	None.
Average	53.93	15.08	3.45	Trace.	None.	.04	None.
Grand average	30.06	39.82	4.92		Trace.	.08	Trace.

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Section E.—Section E is 12⅕ miles south of section A. (See Table 14.)

TABLE 14.—*Analyses of samples of leached ore taken at a point 12⅕ miles south of Red Mountain Gap*

Sample No., feet	Constituents, per cent					Sample No., feet	Constituents, per cent				
	Fe	SiO_2	Al_2O_3	CaO	P		Fe	SiO_2	Al_2O_3	CaO	P
1	20.3	59.1	7.5	None.	0.02	64	10.7	69.7	10.0	None.	Trace.
2	25.8	56.1	4.3	None.	.01	65	8.1	76.1	8.7	None.	None.
3	24.5	58.6	3.6	None.	.02	66	5.8	74.0	12.4	None.	0.0
4	25.5	56.5	4.6	None.	Trace.	67	2.8	82.1	8.5	None.	.0
5	23.9	57.5	5.0	None.	.02	68	3.3	79.4	9.9	None.	.0
6	19.5	65.2	4.2	None.	.02	69	8.1	69.7	12.4	None.	.0
7	18.3	67.0	5.8	None.	.02	70	7.0	71.3	13.0	None.	.0
8	18.4	67.0	5.5	None.	.02						
9	20.4	64.2	4.1	None.	.02	Average	6.54	74.61	10.70	None.	
10	17.8	68.5	4.3	None.	Trace.						
11	17.8	66.5	6.2	None.	Trace.	71	3.4	81.5	8.3	None.	Trace.
12	24.8	56.8	4.5	None.	.02	72	4.6	70.1	15.4	None.	.0
13	23.6	57.4	4.6	None.	.03	73	8.7	69.6	10.9	None.	None.
14	21.0	63.0	3.5	None.	.02	74	3.0	81.3	10.0	None.	None.
15	18.2	65.8	4.0	None.	Trace.	75	4.5	81.5	8.1	None.	None.
16	19.7	63.6	4.3	None.	Trace.	76	4.0	83.2	7.8	None.	None.
17	17.2	69.1	3.4	None.	.02	77	24.3	52.3	7.7	None.	Trace.
18	17.3	70.9	3.1	None.	.02	78	31.0	43.7	5.9	None.	None.
19	14.8	73.2	3.8	None.	.03	79	26.4	51.3	4.2	None.	Trace.
20	46.3	23.2	4.0	None.	.34	80	20.1	59.0	5.5	None.	Trace.
21	32.4	47.6	3.8	None.	.02	81	7.5	73.0	7.8	None.	None.
22	34.5	45.0	3.9	None.	.02	82	6.9	77.7	10.1	None.	None.
23	36.1	41.5	3.3	None.	.01	83	14.9	74.8	3.5	None.	Trace.
24	35.5	42.5	4.4	None.	.02	84	8.5	80.4	5.6	None.	Trace.
25	30.5	48.3	5.1	None.	.02	85	10.1	76.0	7.2	None.	Trace.
26	34.4	44.1	4.1	None.	Trace.	86	9.6	77.7	6.0	None.	Trace.
27	21.2	57.0	6.0	None.	.02	87	6.7	78.3	7.9	None.	Trace.
28	18.4	57.5	10.7	None.	Trace.	88	3.0	87.1	5.9	None.	None.
29	21.2	60.0	6.0	None.	.01	89	21.5	58.8	5.2	None.	Trace.
30	30.6	49.6	3.8	None.	Trace.	90	8.2	77.1	7.4	None.	Trace.
31	23.5	57.2	5.7	None.	Trace.	91	26.2	42.1	6.3	None.	Trace.
32	25.6	55.8	4.7	None.	.03	92	12.4	63.8	12.3	None.	Trace.
33	21.8	60.8	5.1	None.	Trace.						
34	9.7	75.0	6.2	None.	Trace.	Average	12.06	70.0	7.6	None.	Trace.
35	23.0	60.0	4.0	None.	Trace.						
36	26.0	56.3	4.3	None.	.02	93	55.9	13.0	4.6	None.	Trace.
37	19.6	63.8	4.8	None.	.01	94	56.0	12.0	4.6	None.	None.
38	22.0	58.9	5.0	None.	.03	95	44.5	13.0	5.2	None.	None.
39	17.5	67.9	6.1	None.	.02	96	53.8	14.5	4.8	None.	Trace.
40	3.3	85.0	7.5	None.	.03	97	55.5	12.7	4.8	None.	Trace.
41	4.5	82.1	8.2	None.	.04	98	55.0	13.3	4.6	None.	Trace.
42	13.7	72.6	5.7	None.	Trace.	99	54.4	14.8	4.1	None.	None.
43	14.6	73.0	4.4	None.	.02	100	46.6	25.0	4.5	None.	Trace.
44	2.7	84.4	8.6	None.	.01						
45 [a]	12.7	75.5	4.1	None.	.01	Average	52.7	14.7	4.6	None.	Trace.
Average	21.5	61.1	5.0	None.							
						101	26.7	47.8	8.0	None.	Trace.
60	37.5	40.7	3.4	None.	.02	102	34.6	37.3	7.0	None.	Trace.
61	40.0	37.9	3.6	None.	.03	103	45.8	23.1	6.6	None.	Trace.
62	39.2	39.6	3.5	None.	.02	104	39.9	30.1	7.2	None.	Trace.
63	36.0	41.4	5.2	None.	Trace.	105	31.4	44.7	6.0	None.	Trace.
Average	38.1	39.9	3.9	None.		Average	37.9	33.8	6.7	None.	Trace.
						Grand average	22.35	57.95	5.33	None.	

[a] Between samples 45 and 60 is 15 feet of shale.

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Section F.—Section F is 13⅕ miles south of section A. (See Table 15 and fig. 20.)

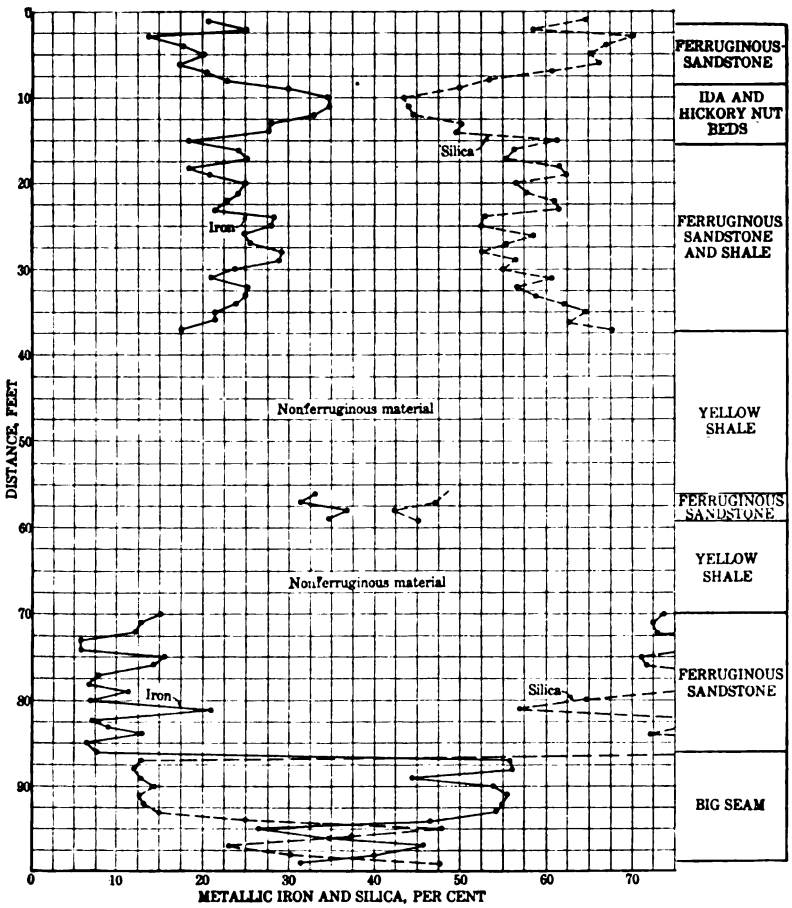

FIGURE 20.—Variations in iron and silica content of ferruginous materials from the top of the Ida bed to the bottom of the Big Seam, 13⅕ miles south of Red Mountain Gap; outcrop or leached ore

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TABLE 15.—*Analyses of samples of leached ore taken at a point 13⅛ miles south of Red Mountain Gap*

Sample No., feet	Constituents, per cent				
	Fe	SiO_2	Al_2O_3	CaO	P
1	20.6	64.8	3.5	None.	Trace.
2	25.2	58.5	5.2	None.	Trace.
3	14.0	70.3	4.4	None.	None.
4	17.9	67.1	4.1	None.	Trace.
5	20.1	65.4	3.4	None.	Trace.
6	17.4	66.3	3.4	None.	Trace.
7	21.5	60.6	3.3	None.	Trace.
8	27.7	53.5	4.3	None.	None.
Average	20.5	63.3	3.95	None.	Trace.
9	30.1	50.0	4.0	None.	Trace.
10	34.4	43.6	4.1	None.	Trace.
11	34.8	44.1	3.5	None.	Trace.
12	33.1	44.5	3.3	None.	Trace.
13	28.1	50.2	5.5	None.	Trace.
14	28.1	49.6	5.6	None.	Trace.
15	18.5	61.4	6.2	None.	Trace.
Average	29.5	49.0	4.60	None.	Trace.
16	24.1	56.2	4.7	None.	Trace.
17	25.2	55.4	4.7	None.	Trace.
18	18.5	61.4	7.0	None.	Trace.
19	21.0	62.3	4.2	None.	Trace.
20	25.0	56.6	4.6	None.	Trace.
21	24.4	57.7	3.9	None.	None.
22	22.8	60.9	3.8	None.	Trace.
23	21.6	61.4	4.3	None.	Trace.
24	28.3	52.9	3.5	None.	Trace.
25	28.2	52.5	3.7	None.	Trace.
26	24.9	58.6	3.5	None.	Trace.
27	25.6	55.4	4.7	None.	Trace.
28	29.4	52.6	3.3	None.	Trace.
29	29.2	56.4	3.3	None.	Trace.
30	23.8	55.2	4.3	None.	Trace.
31	21.1	60.6	4.9	None.	Trace.
32	25.2	56.7	3.3	None.	Trace.
33	25.1	58.8	2.9	None.	Trace.
34	24.2	62.2	1.9	None.	Trace.
35	21.5	64.6	2.4	None.	None.
36	21.5	62.6	3.0	None.	None.
37 [a]	17.5	67.6	3.7	None.	Trace.
Average	24.0	58.6	3.8	None.	Trace.
56	33.0	48.2	3.8	None.	Trace.
57	31.3	47.0	4.4	None.	Trace.

Sample No., feet	Constituents, per cent				
	Fe	SiO_2	Al_2O_3	CaO	P
58	36.7	42.2	2.7	None.	Trace.
59 [b]	34.6	45.2	3.0	None.	Trace.
Average	33.9	45.6	3.4	None.	Trace.
70	15.20	63.7	3.75	None.	Trace.
71	13.0	72.5	4.7	None.	Trace.
72	12.7	72.9	4.1	None.	0.02
73	5.7	82.0	6.2	None.	Trace.
74	5.8	80.3	7.3	None.	None.
75	15.6	71.0	3.2	None.	Trace.
76	14.3	70.6	4.8	None.	Trace.
77	7.9	80.5	5.7	None.	Trace.
78	6.7	82.0	4.1	None.	Trace.
79	11.5	77.6	3.1	None.	None.
80	7.1	64.8	12.8	None.	Trace.
81	21.1	56.8	4.7	None.	Trace.
82	7.3	75.2	7.3	None.	Trace.
83	9.1	78.5	4.6	None.	Trace.
84	13.0	72.3	4.9	None.	Trace.
85	6.7	80.5	4.6	None.	Trace.
86	7.6	80.6	4.1	None.	Trace.
Average	10.6	74.5	5.29	None.	Trace.
87	55.9	13.0	4.6	None.	Trace.
88	56.0	12.0	4.6	None.	None.
89	44.5	13.0	5.2	None.	None.
90	53.8	14.5	4.8	None.	Trace.
91	55.5	12.7	4.8	None.	Trace.
92	55.0	13.3	4.6	None.	Trace.
93	54.4	14.8	4.1	None.	None.
Average	53.58	13.33	4.67	None.	None.
94	46.6	25.0	4.5	None.	Trace.
95	26.7	47.8	8.0	None.	Trace.
96	34.6	37.3	7.0	None.	Trace.
97	45.8	23.1	6.6	None.	Trace.
98	39.9	30.1	7.2	None.	Trace.
99	31.4	44.7	6.0	None.	Trace.
Average	35.68	36.60	6.96	None.	Trace.
Grand average	25.6	54.8	4.6	None.	Trace.

[a] Between samples 37 and 56 is 19 feet of shale.

[b] Between samples 59 and 70 is 11 feet of shale.

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The iron and silica content of the ferruginous sandstone and the ore is given in the sections shown in Figure 21; at the bottom of each section is the average iron and silica content of the ferruginous materials in the sections. Plotting the average figures in a line parallel with the outcrop gives the graphs shown in the upper part of Figure 22.

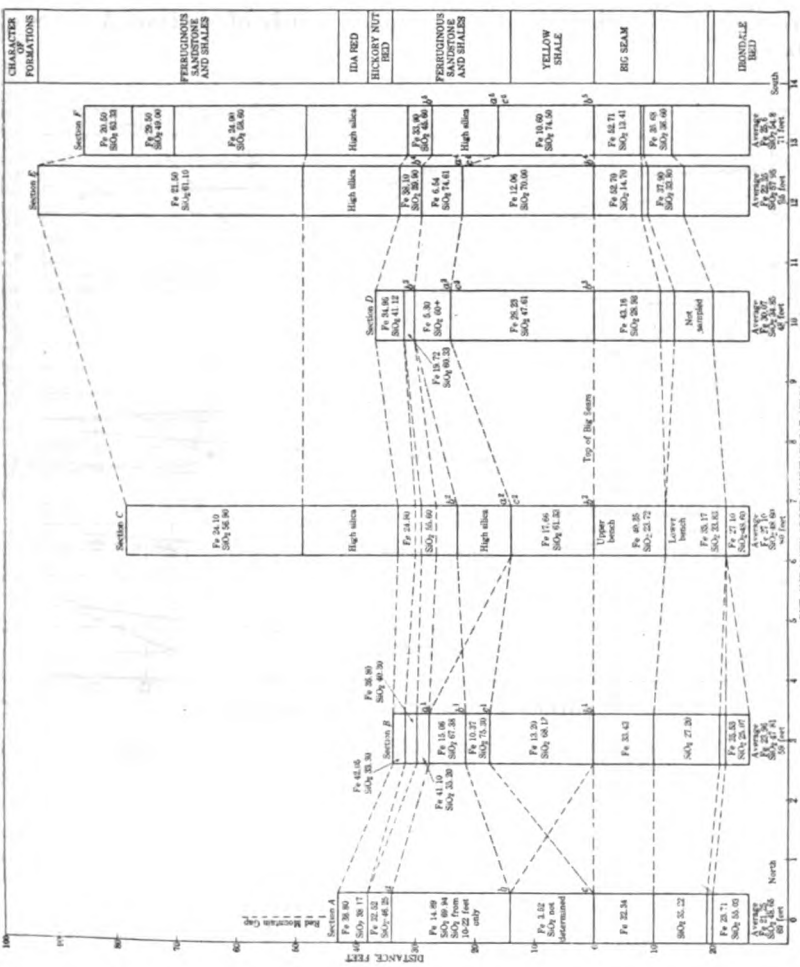

FIGURE 21.—Diagram showing sections at certain intervals along Red Mountain, with thickness of formations and iron and silica content. Total iron and silica content is given for the full sections except where marked "high silica." All samples were in the leached area and show the ferruginous materials along the outcrop of the Big Seam

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GRADE OF UNLEACHED ORE AND SANDSTONE

In order to compare the iron and silica content of leached ores with that of unleached ores and sandstone, a series of samples was taken from diamond-drill cores by splitting the cores. The results of this sampling are given in the sections recorded below.

Section G.—Section G represents a location about 1 mile from the outcrop of the Big Seam and 13⅕ miles south of section A. (See Table 16.)

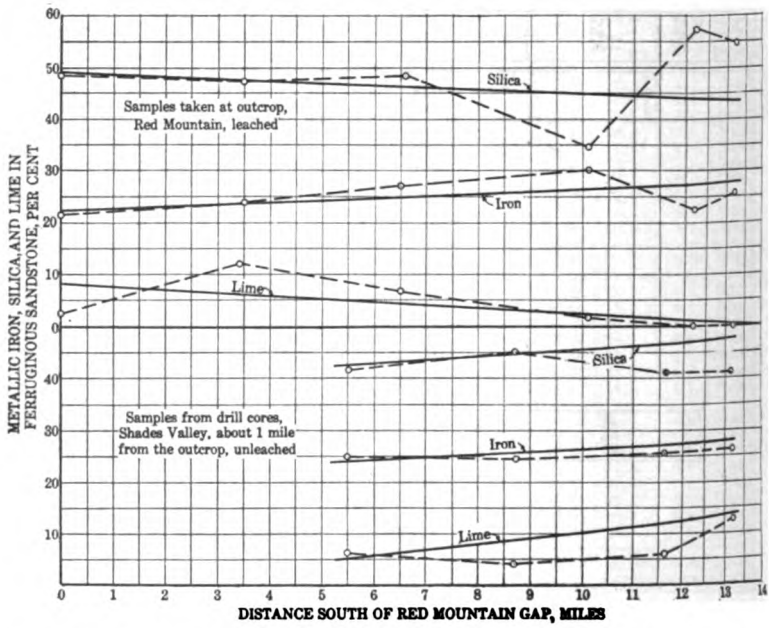
METALLIC IRON, SILICA, AND LIME IN FERRUGINOUS SANDSTONE, PER CENT
Samples taken at outcrop, Red Mountain, leached
Silica
Iron
Lime
Samples from drill cores, Shades Valley, about 1 mile from the outcrop, unleached
Silica
Iron
Lime
DISTANCE SOUTH OF RED MOUNTAIN GAP, MILES

FIGURE 22.—Diagrams showing character of ferruginous materials in the Clinton formation, including the Big Seam on Red Mountain and in Shades Valley

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TABLE 16.—*Analyses of samples of unleached material taken from drill core at a point 13⅗ miles south of Red Mountain Gap*

Sample No., feet	Constituents, per cent					Sample No., feet	Constituents, per cent				
	Fe	SiO_2	Al_2O_3	CaO	P		Fe	SiO_2	Al_2O_3	CaO	P
1	13.4	54.4	4.7	4.6	0.07	28	17.2	62.4	5.2	None.	0.08
2	23.4	55.8	3.4	.7	.06	29	12.6	66.6	6.2	None.	.05
3	27.3	53.0	3.2	None.	.07						
4	25.7	51.8	3.2	.9	.05	Average	25.52	53.87	3.90	0.23	.07
5	23.4	57.2	3.4	None.	.08						
6	26.0	56.4	3.2	None.	.06	30	27.5	10.5	2.6	22.7	.....
7	31.3	48.4	3.3	None.	.05	31	24.7	6.6	2.5	27.7	.....
8	28.4	49.8	3.0	.5	.06	32	35.0	9.3	2.3	17.9	.....
9	31.3	47.4	3.1	None.	.09	33	36.2	9.9	3.0	16.1	.....
10	32.8	47.2	2.4	None.	.09	34	38.8	7.2	3.2	14.8	.....
11	35.5	42.0	3.4	None.	.09	35	33.3	7.6	2.5	18.9	.....
12	34.9	42.0	3.4	None.	.09	36	26.5	5.1	2.4	27.6	.....
13	33.1	45.4	3.2	None.	.10	37	36.5	9.9	2.4	15.0	.....
14	31.3	57.6	3.3	None.	.08	38	36.4	5.0	2.7	18.5	.....
15	31.4	47.8	3.2	Trace.	.09						
16	27.2	51.6	4.2	None.	.05	Average	32.76	7.90	2.62	19.91	.....
17	30.7	47.8	3.5	None.	.08						
18	26.6	52.8	3.0	None.	.08	39	20.3	34.8	5.3	11.2	.12
19	25.9	54.2	3.9	Trace.	.10	40	16.4	36.2	6.6	10.4	.12
20	27.1	51.2	4.4	None.	.06	41	18.0	23.2	3.9	4.3	.08
21	24.0	65.0	4.2	None.	.09	42	26.6	20.2	3.4	4.3	.13
22	21.3	59.6	4.6	None.	.05						
23	23.0	57.8	3.5	None.	.06	Average	20.32	28.60	4.80	7.55	.11
24	23.8	57.2	3.3	None.	.08						
25	25.1	52.8	4.0	Trace.	.08	Grand average	26.58	41.61	3.71	*12.71	.07
26	17.1	58.8	6.8	None.	.04						
27	9.5	68.4	6.9	Trace.	.06						

* An approximate lime content taken representing the full section. This has been done for all sections of unleached material.

Section H.—Section H represents a location about 11⅗ miles south of section A. (See Table 17.)

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TABLE 17.—*Analyses of samples of unleached material taken from drill core at a point 11⅜ miles south of Red Mountain Gap*

Sample No., feet	Constituents, per cent					Sample No., feet	Constituents, per cent				
	Fe	SiO_2	Al_2O_3	CaO	P		Fe	SiO_2	Al_2O_3	CaO	P
1	20.5	55.6	3.1	2.1	0.09	41	20.0	60.2	5.2	Trace.	0.09
2	24.3	53.8	10.9	1.4	.04	42	8.6	68.0	10.2	None.	.08
3	13.0	62.0	7.0	1.9	Trace.	43	11.3	66.2	8.2	None.	.03
4	28.0	48.2	4.0	1.6	Trace.	44	8.1	68.6	9.5	Trace.	.04
5	21.9	53.4	6.6	Trace.	.08	45	7.3	69.0	7.9	.4	.04
6	27.5	50.4	4.5	None.	.09	46	4.9	53.6	7.4	Trace.	.03
7	27.8	52.0	4.0	None.	.09						
8	27.5	52.6	11.0	None.	.06	Average	9.15	66.31	8.05	.01	.04
9	30.5	47.0	4.1	Trace.	.09						
10	27.8	52.0	3.5	Trace.	.06	47	39.0	14.4	4.0	10.7	.....
11	28.7	50.6	3.4	None.	.09	48	29.6	5.5	2.2	24.6	.....
12	29.6	50.0	3.0	None.	.08	49	34.3	8.0	1.8	18.1	.....
13	28.9	52.2	3.3	Trace.	Trace.	50	28.8	8.5	1.9	20.7	.....
14	25.3	56.2	2.4	Trace.	.09	51	41.5	6.9	2.1	12.6	.....
15	25.6	55.6	2.8	Trace.	Trace.	52	20.3	6.5	1.6	32.0	.....
16	33.2	42.4	3.8	0.5	.16	53	22.6	8.8	1.7	28.0	.....
17	30.9	49.0	3.6	Trace.	.08	54	8.3	3.4	1.6	44.9	.....
18	31.7	47.2	3.9	Trace.	.11	55	35.3	10.9	2.6	17.5	.....
19	30.4	48.6	2.9	Trace.	.09	56	35.5	9.9	2.3	16.6	.....
20	30.7	49.2	2.6	Trace.	.10	57	34.2	7.2	2.1	19.4	.....
21	37.5	59.4	3.2	None.	.09	58	37.5	9.3	2.4	15.5	.....
22	31.5	47.0	2.5	Trace.	.11	59	31.8	9.0	2.4	19.7	.....
23	31.4	48.2	3.4	None.	.07	60	35.4	10.4	3.2	16.3	.....
24	29.2	50.6	3.2	None.	.08						
25	33.1	44.6	3.8	Trace.	Trace.	Average	31.0	8.47	2.28	21.18	.....
26	32.0	48.8	2.3	Trace.	.09						
27	32.2	46.8	3.2	None.	.10	61	15.5	46.4	13.0	2.7	.18
28	29.4	50.6	3.0	None.	.16	62	17.4	46.8	10.7	2.1	.45
29	36.6	41.2	3.2	Trace.	.11	63	24.9	23.6	5.5	12.6	.15
30	34.7	42.2	3.3	None.	.14	64	16.0	27.6	6.4	18.1	.09
31	32.8	44.4	3.6	None.	.13	65	28.5	30.0	4.0	9.0	.13
32	29.4	51.2	2.6	None.	.11	66	23.1	30.2	6.1	12.2	.14
33	26.7	53.4	3.4	Trace.	.10	67	32.0	22.2	4.2	9.7	.17
34	23.1	61.6	2.4	Trace.	.09	68	31.7	20.8	3.7	10.2	.11
35	25.3	55.4	2.8	.4	.08	69	33.7	17.4	3.6	12.4	.13
36	26.1	52.8	3.5	Trace.	.08	70	26.1	22.6	5.0	12.5	.25
37	13.9	65.8	8.0	.4	.07						
						Average	24.9	28.7	6.2	10.1	.17
Average	28.3	51.1	3.9	.2	.08						
						Grand average	25.91	41.35	4.49	5.20	.09
38	10.0	66.4	8.0	Trace.	.05						
39	7.0	74.4	6.2	0.5	.03						
40	5.2	70.4	10.1	Trace.	.03						

NOTE.—Samples 38 to 46, inclusive, were omitted in average used in graph, Figure 22, because the iron content was too small to be considered.

Section I.—Section I represents a location about 8 $\frac{7}{10}$ miles south of section A. (See Table 18.)

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TABLE 18.—*Analyses of samples of unleached material taken from drill core at a point 8 1/16 miles south of Red Mountain Gap*

Sample No., feet	Constituents, per cent					Sample No., feet	Constituents, per cent				
	Fe	SiO_2	Al_2O_3	CaO	P		Fe	SiO_2	Al_2O_3	CaO	P
1	13.7	58.2	3.5	6.3	0.06	35	33.2	12.6	2.3	16.4	Trace.
2	19.0	54.6	4.4	3.3	.06	36	26.3	12.9	3.0	19.5	Trace.
3	15.0	56.6	8.5	1.6	.08	37	43.6	11.2	2.6	9.2	Trace.
4	21.6	56.4	3.4	1.3	.06	38	41.9	16.4	2.2	6.9	Trace
5	20.5	58.4	3.2	2.1	.06	39	35.4	9.4	2.0	16.9	Trace.
6	24.0	50.4	2.9	2.5	.07	40	47.5	12.4	2.3	6.9	Trace.
7	23.5	54.8	3.1	1.1	.08	41	46.9	15.3	1.6	5.6	Trace.
8	23.3	53.0	2.9	2.5	.07						
9	28.6	48.2	3.0	.6	.09	Average	39.2	12.8	2.2	11.6	Trace.
10	21.5	56.8	2.8	2.2	.06						
11	18.0	56.8	3.1	4.5	Trace.	42 [b]	21.7	63.0	1.6	None.	0.11
12	15.5	59.0	6.6	1.3	.06	43	24.1	54.4	3.5	1.2	.08
13	20.7	54.4	5.1	2.2	.08	44	31.5	40.0	4.0	1.9	.15
14	30.5	47.0	3.7	Trace.	.11	45	27.8	44.8	4.9	.9	.15
15	21.7	54.0	5.9	Trace.	.08	46	21.3	50.0	3.3	4.2	.06
16	24.9	53.0	4.4	Trace.	.03						
17	20.3	60.4	5.6	Trace.	.08	Average	25.2	50.4	3.4	1.6	.11
18	22.5	58.0	4.4	Trace.	Trace.						
19	23.7	56.4	5.2	Trace.	.08	47	21.7	38.6	4.5	8.8	.09
20	24.9	51.6	5.6	Trace.	.09	48	23.4	26.8	6.0	12.4	.18
21	30.5	48.6	3.6	None.	.12	49	17.1	22.0	5.4	20.5	.12
22	27.9	52.2	3.0	None.	.12	50	20.7	19.2	2.9	12.8	.12
23	28.1	53.0	2.8	None.	.08	51	20.1	35.0	4.5	11.2	.14
24	28.6	52.6	2.5	None.	.10	52	21.4	30.4	3.5	15.4	.13
25	29.6	50.2	3.8	None.	.14	53	19.2	20.0	2.5	23.2	.12
26	28.5	53.0	2.8	None.	.13	54	24.3	20.2	7.3	16.6	.14
27	25.8	51.8	2.2	None.	.15						
28	24.0	60.2	1.7	None.	.10	Average	20.9	26.5	4.5	15.1	.13
29	25.8	54.6	2.8	None.	.11						
30 [a]	25.8	53.8	2.4	Trace	.09	Grand average	24.9	45.1	3.8	4.6	.07
31	23.8	59.0	4.9	None.	.09						
32	15.2	62.8	7.5	Trace.	.07						
33	17.0	64.2	5.4	Trace.	.06						
34	14.2	69.0	3.4	None.	.06						
Average	22.9	55.3	4.0	.9	.08						

[a] Represents 8 inches only.

[b] Represents 6 inches only.

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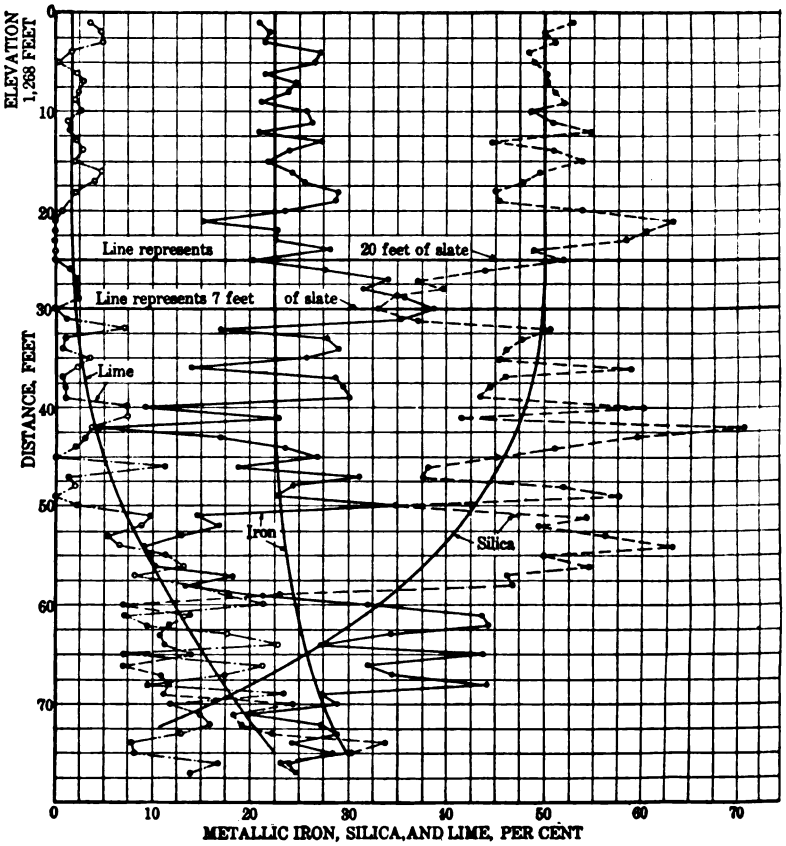

FIGURE 23.—Iron, lime, and silica content of ferruginous materials in the Clinton formation of the Birmingham district, Alabama, about 1 mile from the outcrop on Red Mountain, in Shades Valley

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Section J.—Section J represents a location about 5½ miles south of section A. (See Table 19 and fig. 23.)

TABLE 19.—*Analyses of samples of unleached material taken from drill core at a point 5½ miles south of Red Mountain Gap*

Sample No., feet	Constituents, per cent					Sample No., feet	Constituents, per cent				
	Fe	SiO_2	Al_2O_3	CaO	P		Fe	SiO_2	Al_2O_3	CaO	P
1	21.0	52.8	2.8	3.8	0.07	42	4.5	70.8	6.4	3.7	0.09
2	22.2	50.0	3.1	4.7	.07	43	17.1	59.6	5.3	3.0	.12
3	21.6	50.6	3.2	4.8	.08	44	23.7	51.2	4.0	2.0	.10
4	27.1	48.4	3.8	1.6	.10	45	27.0	45.2	5.3	Trace.	.15
5	26.4	48.8	4.1	.9	.09	46	18.9	38.0	2.9	11.2	.06
6	21.6	50.2	4.9	2.4	.07	47	31.0	37.6	6.5	1.3	.13
7	24.8	50.2	3.0	3.0	.10	48	24.6	52.2	2.9	1.8	.10
8	24.0	51.2	3.4	2.5	.07	49	22.8	57.6	2.1	Trace.	.10
9	21.1	52.0	5.0	2.1	.07	50	34.8	35.0	5.2	2.2	.19
10	25.8	48.6	3.1	2.7	.06	51	14.6	54.4	1.3	9.7	.08
11	26.3	50.8	2.7	1.4	.08	52	16.8	49.4	2.9	9.0	.09
12	20.8	54.6	4.5	1.5	.06	53	12.7	56.4	3.8	5.5	.06
13	27.4	44.6	4.3	2.3	.10	54	9.2	63.2	1.9	6.5	Trace.
14	24.0	51.0	3.2	2.9	.08	55	9.7	50.0	1.7	11.3	Trace.
15	21.9	54.0	3.8	2.1	.05	56	10.1	54.6	1.7	13.1	.08
16	24.3	49.6	2.6	4.7	.06	57	18.3	46.4	4.7	8.0	.08
17	25.5	47.8	2.4	4.2	.06	58	13.3	46.8	1.6	14.5	.06
18	29.0	45.0	2.9	2.4	.07	59	21.3	23.0	4.7	18.0	.15
19	28.9	45.4	4.8	.8	.12						
20	23.5	54.0	4.7	.7	.08	Average	20.1	49.1	3.8	5.5	.08
21	15.2	63.2	5.8	Trace.	.05						
22	17.9	60.4	5.6	Trace.	.05	60	31.90	7.00	2.00	21.40	Trace.
23	17.6	58.4	6.3	Trace.	.07	61	43.70	13.80	2.01	7.20	Trace.
24	28.1	48.8	4.3	Trace.	.10	62	44.30	11.70	2.08	9.50	Trace.
25	20.4	52.2	3.8	Trace.	.10	63	34.50	10.90	2.50	17.50	Trace.
						64	27.40	11.20	1.90	23.00	Trace.
Average	23.4	51.3	3.9	2.0	.07	65	43.70	13.80	2.01	7.20	Trace.
						66	31.90	7.00	2.00	21.40	Trace.
26	27.6	44.0	5.6	1.5	.07	67	34.50	10.90	2.50	17.50	Trace.
27	34.1	37.2	3.3	2.2	.09	68	44.30	11.70	2.08	9.50	Trace.
28	31.4	39.8	4.4	2.2	.11	69	27.40	11.20	1.90	23.50	Trace.
29	35.8	35.2	3.5	2.4	.14						
30	38.9	33.2	3.8	Trace.	.12	Average	36.36	10.92	2.09	15.77	Trace.
31	35.4	37.0	3.5	1.2	.15						
						70	28.9	24.6	4.0	11.9	.17
Average	33.8	37.7	4.0	1.5	.11	71	19.8	18.4	2.1	15.0	.16
						72	27.3	19.2	3.1	15.8	.15
32	17.0	50.6	2.7	7.2	.05	73	28.9	22.4	3.8	12.8	.14
33	27.7	47.8	4.5	1.0	.15	74	24.3	33.6	7.1	7.9	.13
34	29.0	46.2	3.8	.6	.14	75	28.4	30.2	4.6	8.1	.11
35	25.8	45.4	3.9	3.7	.07	76	24.1	23.2	3.6	16.8	.13
36	14.0	59.0	6.4	2.4	.04	77	24.6	24.6	5.0	13.8	.12
37	28.7	46.2	3.9	.7	.10						
38	29.5	44.4	4.4	.9	.13	Average	25.7	24.5	4.1	12.7	.12
39	30.1	43.4	4.4	.8	.10						
40	9.2	60.2	4.4	7.9	Trace.	Grand average	24.98	41.43	3.68	6.16	.08
41	23.1	41.6	3.8	8.0	.09						

Plotting the average iron and silica content of the ferruginous materials in the above sections along a line parallel with the outcrop gives the graphs shown in the lower part of Figure 22. These graphs permit ready comparison of the iron and silica content.

In both leached and unleached materials the iron and silica content is practically the same, showing about the same degree of variation from north to south. The lime content of the unleached and leached rocks is reversed, however, increasing from north to south in the former and decreasing in the latter; as the average content includes the ores of the Big Seam, it is probable that the variations in the constituents of the ferruginous materials conform closely to their occurrence in the Big Seam.

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Section K.—Section K represents a location some 3 miles from the outcrop of the Big Seam on Red Mountain and about 8 $\frac{7}{10}$ miles south of section A. (See Table 20.)

TABLE 20.—*Analyses of samples of unleached material taken from drill core at a point about 3 miles from the outcrop and 8.7 miles south of Red Mountain Gap*

Sample No., feet	Constituents, per cent					Sample No., feet	Constituents, per cent				
	Fe	SiO_2	Al_2O_3	CaO	P		Fe	SiO_2	Al_2O_3	CaO	P
1	25.7	54.8	2.2	0.7	0.14	24	20.7	62.2	3.1	0.5	0.10
2	25.2	56.8	1.9	Trace.	.14	25[c]	20.8	63.2	2.1	Trace.	.11
3	25.2	56.6	1.8	None.	.10						
4	25.7	53.6	2.7	Trace.	.13	Average	20.77	62.70	2.6	2.5	.10
5	29.2	49.4	2.9	Trace.	.13						
6	26.2	54.2	3.0	None.	.09	40	17.4	57.6	4.2	2.8	0.09
7	24.6	57.4	2.9	Trace.	.11	41	28.9	42.4	4.6	1.0	.20
8	25.5	55.2	3.1	.4	.11	42	14.3	60.6	4.3	3.1	.08
9	24.5	58.6	2.4	Trace.	.10	43	12.7	62.4	3.9	3.6	.08
10	27.6	55.4	2.3	None.	.10	44	12.5	62.2	5.3	2.3	.12
11[a]	28.5	52.4	3.1	Trace.	.14	45	7.8	69.8	4.3	3.3	.09
						46	10.5	65.4	7.1	2.3	.06
Average	26.17	54.85	2.57	.01	.11						
						Average	14.87	60.05	4.81	2.62	.09
14	24.9	56.8	2.6	Trace.	0.11						
15	24.6	55.8	3.4	None.	.11	Grand average	22.55	57.23	3.18	0.74	0.11
16	25.7	52.0	2.6	None.	.10						
17	26.7	55.0	2.2	.3	.12						
18	26.4	52.0	4.0	.3	.13						
19	23.0	61.0	2.4	.3	.11						
20	24.3	59.0	2.8	None.	.12						
21[b]	22.3	61.8	2.0	None.	.09						
Average	24.73	56.57	2.75	.11	.11						

[a] Between samples 11 and 14 is 3 feet of ferruginous sandstone and shale.
[b] Between samples 21 and 24 is 3 feet of ferruginous sandstone and shale.
[c] Between samples 25 and 40 is 15 feet of nonferruginous sandstone.

The above samplings and analyses give an excellent idea of the amount and grade of the ferruginous materials in the Clinton formation; further, the effect of leaching by percolating waters, whereby the lime is reduced and the iron and silica content is increased, is shown to advantage.

RATIO OF IRON TO OTHER CONSTITUENTS OF ORE

The ratio of iron to silica, lime, alumina, and other constituents of ore is of value in connection with the metallurgical treatment of the ore in respect to the improvement in grade by concentration and in respect to furnace practice. Ratios of iron to silica, alumina, silica and alumina combined, and lime are given for hard ores in Table 21, and for soft or leached ores in Table 22.

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TABLE 21.—*Ratio of iron to silica, alumina, and lime in hard iron ores, upper bench, Big Seam, Red Mountain*

Location, miles	Constituents, per cent			
	Fe:SiO_2	Fe:Al_2O_3	Fe:CaO	Fe:SiO_2+Al_2O_3
0-.6-1			3.28	1.35
2-.7-3	0.86	11.66		.80
4-.5-5	.97	9.55	3.76	.88
5-.1-6			11.14	.82
6-.4-7	1.36	10.85	3.72	1.21
6-.5-7	1.39	9.86	4.60	1.22
7-.4-8	1.22	10.97	5.71	1.09
9-.0-0	2.02	11.71	2.80	1.72
9-.5-10	3.06	13.87	2.32	2.51
10-.5-11	2.73	13.50	2.39	2.27
11-.1-12	2.26	12.03	2.31	1.90
11-.9-12	2.53	11.61	1.88	2.07
12-.1-13	2.34	12.16	1.92	1.96
12-.5-13			3.06	2.50
12-.9-13	2.89	13.00	2.12	2.36
13-.9-14	2.80	12.46	2.16	2.28
14-.2-15	2.80	12.66	2.21	2.35
14-.9-15	2.90	12.84	2.11	2.36
15-.9-16	3.56	11.21	2.16	2.70
16-.9-17	3.66	10.19	2.11	2.69
17-.5-18	3.05	8.98	1.89	2.28
18-.5-19	3.04	9.06	1.83	2.27
18-.9-19	3.33	12.12	1.87	2.61
19-.1-20	3.53	11.68	1.93	2.71
19-.4-20	3.41	11.40	1.84	2.62
20-.1-21	3.43	11.18	1.80	2.62
20-.2-21	3.24	10.84	1.81	2.49
21-.0-0	3.06	9.42	1.93	2.31
Average	2.61	11.39	3.06	2.03

TABLE 22.—*Ratio of iron to silica, alumina, and lime in the leached ores of Red Mountain*

1. ORES IN UPPER BENCH, BIG SEAM

Location, miles	Constituents, per cent			
	Fe:SiO_2	Fe:Al_2O_3	Fe:CaO	Fe:SiO_2+Al_2O_3
0-.0-0	0.89	8.10	51.64	0.80
4-.5-5	.73	10.16	25.40	.68
5-.5-6	1.08	12.00	11.50	.99
5-.6-6	1.29	12.89	4.37	1.17
6-.4-7	.75	8.35	407.83	.69
7-.4-8	1.38	13.43	9.65	1.25
7-.5-8	1.33	15.10	5.25	1.22
8-.4-9	1.62	14.07	3.31	1.45
9-.3-10	2.13	13.72	13.68	1.84
10-.5-11	2.47	13.58	172.86	2.09
11-.6-12	2.57	15.13	2.65	2.20
12-.1-13	2.68	17.18	3.29	2.32
14-.1-15	3.36	16.50	3.32	2.79
17-.2-18	3.57	15.63		2.91
18-.5-19	3.62	14.31	16.60	2.89
Average	1.17	13.34	48.75	1.68

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TABLE 22.—*Ratio of iron to silica, alumina, and lime in the leached ores of Red Mountain*—Continued

2. ORES IN LOWER BENCH, BIG SEAM

Location, miles	Constituents, per cent			
	Fe:SiO_2	Fe:Al_2O_3	Fe:CaO	Fe:SiO_2+Al_2O_3
4-.5-5	0.58	7.99	11.14	0.54
5-.5-6	.66	7.94	3.81	.61
5-.6-6	.68	8.43	6.37	.63
6-.4-7	1.39	12.11	626.57	1.25
7-.4-8	1.00	12.01	3.48	.92
7-.5-8	1.07	26.01	3.48	1.02
8-.4-9	.89	8.92	2.82	.81
10-.5-11	1.28	11.28	51.62	1.14
11-.6-12	1.28	12.60	2.80	1.16
12-.1-13	1.69	11.04	.....	1.47
14-.1-15	2.34	17.19	.....	2.06
Average	1.16	12.32	64.73	1.03

3. ORES IN THE IRONDALE BED

0-.0-0	1.78	9.70	3.19	1.50
5-.1-6	.82	6.07	2.18	.72
5-.5-6	.70	4.99	14.07	.61
6-.4-7	.96	6.20	455.25	.83
7-.4-8	.81	8.37	1.44	.74
8-.4-9	.92	7.64	1.65	.82
Average	.99	7.16	79.63	.87

4. ORES IN THE HICKORY NUT BED

4-.5-5	1.06	10.07	42.39	0.95
5-.5-6	.87	8.80	361.10	.79
5-.6-6	.98	9.29	980.50	.88
7-.5-8	.42	6.38	.....	.39
8-.4-9	.74	8.50	.....	.68
8-.6-9	1.06	11.12	.....	.97
9-.0-10	.93	12.73	.....	.87
10-.5-11	1.17	9.44	.....	1.04
11-.6-12	.96	8.80	.....	.86
12-.1-13	.80	10.20	.....	.74
12-.5-13	.81	13.51	.....	.77
13-.8-14	1.28	14.21	.....	1.17
14-.5-15	.48	8.37	.....	.46
14-.9-15	.64	8.14	.....	.59
15-.9-16	.24	4.56	.....	.23
16-.9-17	.47	5.04	.....	.43
18-.9-19	.57	11.60	.....	.55
19-.4-20	.48	8.56	.....	.46
20-.6-21	.50	5.64	.....	.46
Average	.76	9.20	72.84	.70

5. ORES IN THE IDA BED

0-.0-0	0.87	10.04	33.22	0.86
4-.5-5	1.27	14.20	.....	1.16
5-.5-6	1.10	12.56	319.44	1.01
5-.6-6	.83	8.57	444.87	.76
8-.4-9	1.29	11.86	.....	1.16
9-.0-10	1.18	12.10	.....	1.07
11-.1-12	1.64	14.86	.....	1.48
12-.1-13	1.54	12.40	.....	1.37
12-.5-13	1.42	13.07	.....	1.28
13-.9-14	1.28	14.21	.....	1.17
14-.5-15	.96	9.67	.....	.87
14-.9-15	1.09	12.93	.....	1.00
15-.9-16	1.01	10.71	.....	.92
16-.9-17	1.30	10.63	64.81	1.15
Average	1.19	11.98	61.59	1.09

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SUMMARY

An attempt has been made to obtain new and reliable information on the ores in the four ore beds in Red Mountain and to correlate the information so as to be most useful to those interested. Figure 11 gives a diagrammatic representation of the ore beds, showing their average thickness and their relation to each other. The grade of the ore throughout the extent of the Big Seam is also shown, which, supplemented by Figure 15, gives a comprehensive view of the ore situation in the district.

This detailed study of the ferruginous sandstones of the Clinton formation, moreover, throws much light upon possible sources of iron in the district, should means of improving their grade by beneficiation be devised. Figures 17, 18, 19, 20, 21, 22, and 23 show the thickness and the grade of the ferruginous sandstones. The accessibility of much of the ferruginous sandstone and the Big Seam is well known, the slope of Red Mountain on the Shades Valley side conforming closely to that of the dip of the ore bed. The average dip of the ore bed is about 22° and the slope of the surface is nearly 10°. In numerous localities only a few feet of rock overlie the Big Seam which with certain beds of shale would have to be removed should it prove desirable to work the ferruginous sandstones associated with the ore beds. (See fig. 10.)

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